

Fall 2021

## The Effects of Performance Enhancing Drugs in Sports: Legal and Illegal

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*Integrated Studies*. 330.  
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The Effects of Performance Enhancing Drugs in Sports:  
Legal and Illegal

By  
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Project submitted in partial fulfillment of the  
requirements for the  
Bachelor of Integrated Studies Degree

Murray State University  
October 21, 2021

## Abstract

This paper offers valuable information that will inform readers about the effects that come with regularly ingesting dietary and performance enhancing drugs and supplements. The paper goes into depth of specific supplements, concerning what the common man or woman believes the supplement does, versus what the supplement is advertised to do. The paper will provide information on certain test trails performed by others as supporting evidence on how the supplement being discussed plays a role in performance enhancement. The motivation behind this paper is to inform young athletes, or any athlete who considers themselves to be uninformed when it comes to fueling their body with the best supplements for that matter, on what supplements are best suited for them based on their own personal goals. The paper offers information concerning supplements such as creatine, pre-workout, amino acids, proteins, and other varieties of vitamins and supplements.

*Keywords:* Synthesize, supplementation, performance-enhancement

### Acknowledgements

As this paper marks the end of my academic journey at Murray State University, I want to thank my parents for being my ultimate supporters. Mom and Dad, you two have never given up and me, and never let me give up on myself, I love you both.

This idea for this paper has been inspired by Mr. Tim Turner, as he has passed down what seems like infinite knowledge to me about the world of exercise science, and now I would like to share a little of what he has taught me.

Lastly, I want to say thank you to Coach Manny Lherisse. Coach was much more than a coach to me. Not only did he want me to reach my potential in the world of athletics, he always pushed me twice as hard to reach my potential as a student and as a person. He played a major role in shaping me into who I am today. Thank you, coach.

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## Introduction

The world of sports has grown into one of the most competitive fields, if not the most competitive, when comparing it to all other occupations and pastimes over the past 100 years. With it being so competitive, it is only human nature for people to want to gain an edge on their competition by any means possible. Some athletes may go about this the honorable way; training harder, longer, and more frequently. Others may go about one upping their competition by engaging in drug and substance abuse. There is no excuse for this other than the fact that the effects of substance abuse cannot be matched by human effort.

Performance enhancing drugs have been around for about three quarters of a century now, and have been compromising the integrity of athletic competition ever since they were developed. Testosterone, which is the major sex hormone found in males which is credited for body's muscle and bone size and strength (Harvard Health Publishing, 2019, p.1), was first synthesized in Germany back in 1935. The first motive to synthesizing testosterone was to clinically treat depression, but it was not very long until professional athletes discovered that these substances could be abused to enhance their athletic performance, and also improve their physical appearance and body composition. By increasing their testosterone levels, they were also increasing the size of their muscles, cutting their body fat down, which is ultimately the deciding factor of most body building competitions.

Body builders were not the only guilty party when it came to abusing performance enhancing drugs, and they still are not today. In fact, many athletes are still getting away with it today. You may remember athletes like Barry Bonds, who holds the record for most home runs in one player's career with 762. Bonds beat Hank Aaron's record in 2007, which has held for 33 years (Joyce, 2021, p.4). For the next four years, Bonds was under investigation for drug abuse

and for compromising the integrity of competition at the highest level in baseball. Ultimately, Bonds did not face any serious repercussions, as his record is still recognized today, even though he tested positive for performance enhancing drugs on multiple occasions.

Lance Armstrong, who was a professional road cyclist, was convicted of abusing performance enhancing drugs as well. Armstrong had won the Tour de France seven times by the year 2005, which was six years away from his final retirement date. This was the most ever by any cyclist, and he had done it with ease. So, of course questions were going to be raised. It was proven right to raise those questions in 2012, when Armstrong was proven guilty of drug abuse for the improvement of his athletic ability by the U.S. Anti-Doping Agency (USADA), who disqualified Armstrong from all competitive cycling events from 1998 through the present date at the time. This revoked him of his seven Tour de France titles, but is still recognized world-wide as one of the greatest cyclers ever.

These investigations were not even legal until 1990, which is when U.S. Congress passed the Anabolic Steroid Act in response to the increasing levels of illicit traffic in steroid use. “This Act identified anabolic steroids as a separate drug class and categorized over two dozen drugs as controlled substances. The Act also gave a four-part definition of this drug class, which allowed for flexibility in controlling new anabolic steroids as they were synthesized. In 2004, Congress enacted the Anabolic Steroid Control Act of 2004, which banned over-the-counter steroid precursors; increased penalties for making, selling, or possessing illegal steroid precursors; and provided funds for preventative educational efforts” (NIDA, 2018, p.1).

Of course, once a rule is made there will be somebody there to find a loophole in it so they can keep getting away with whatever it was that they were doing before. As stated above, the Anabolic Steroid Act was passed in 1990. Creatine supplementation gained mainstream

popularity following the 1992 Olympic Games in Spain, even though it was first synthesized back in 1832 (Reardon, 2018, p.3). The same can be said for many other supplements that will be discussed throughout the remainder of the paper.

These supplements are not illegal, at least in most professional sports organizations, because they do not yield the same results as anabolic steroids or amphetamines. However, they do still assist with muscle growth and strength. The difference is that you cannot just pull out a needle and make no changes in your lifestyle and expect to see major jumps in performance like you can with steroids. These legal supplements require the consumer to take them at a specific time, at a specific frequency, in a specific amount, or perhaps even a combination of the three.

This is dangerous for the many young athletes today who have turned to these supplements because they do not see the growth that they are hoping to make in a certain amount of time that they had predetermined in their head. While yes, many young athletes do turn to anabolic steroids and amphetamines because they are guaranteed results, good or bad, when taking those. For those who turn to the legal supplements, or what they think are legal, often go about it misinformed and misguided. Through the power of social media like Instagram and Twitter especially, these young athletes see videos of their favorite players working out and promoting the supplements that they claim to take or that they are sponsored by and decide to go out and buy it right away without doing any further research on the product. The first thought that pops into their head is that since that guy or girl that posted the video is clearly taking the supplement and they are a perfectly sculpted physique, even though more often than not there is never actual video of them taking it, just promoting it, then if they themselves take the same supplement, they will end up just like him or her.

This claim can be supported by the report given to the public from The National Center for Biotechnology Information concerning the substance use rates among different populations of athletes. As of 2018, two percent of professional athletes across all sports admitted to taking substances banned by the World Anti-Doping Agency, and or failing a drug test within the past year. Six percent of all high school students involved in athletics admitted to abusing supplements and performance enhancers to improve performance in the past year. Five percent of male athletes in college admitted to using anabolic steroids, and two percent of female collegiate athletes admitted their abuse (Reardon, 2018, p.2).

To think that the rate is higher among high school athletes than it is for professional athletes, and only one percent lower than collegiate athletes should be alarming to parents, coaches, and others helping shape the lives of a young athletes. Especially when you consider that in a separate survey that 87% of the high schoolers who admitted to abusing supplements and performance enhancers regret taking whatever they it is that they abused. It was recorded that most of those athletes regretted their decisions solely based on the fact that none of them really knew why they were taking the supplements, other than they had heard somebody else was taking it who was in phenomenal shape (Reardon, 2018, p.2). This is a big reason that young athletes, high school or college, walk into a drug test expecting to pass and end up failing; they end up facing repercussions such as time in rehabilitation, suspension, or dismissal from the team.

There has been a research base done that demonstrates the many effects of performance enhancing agents. Most of these have come back as having a positive output in terms of performance enhancement. However, some substances like antiestrogens and receptor modulators are commonly used to enhance performance, yet have very little, if any data backing

up that very claim. That is exactly what this paper is going to dive into throughout the remainder of the text. Supplements and performance enhancers that are classified as androgens, growth hormone influencers, stimulants, nutritional supplements, and oxygen transporters, will all be investigated in an effort to simplify the true reasoning for taking a supplement like that.

Hopefully, young athletes around the country will at least read up to this point and realize the importance of doing extensive research on a product before making an irreversible decision, because in most cases, those decisions have no foreseeable positive outcome. Meaning that the supplement that the athlete is taking will probably not help them reach their specific goals that they have set for themselves. It is an American tradition for people to want to take the easy way out when they reach a plateau in their progress, or face any kind of adversity for that matter. With how easy it is for somebody to get their hands on a workout stimulant loaded up with caffeine, taurine, and other substances that can be considered illegal in large quantities when competing at a high level in athletics, it is more than easy for a struggling athlete to turn to an over-the-counter supplement that vaguely promises a performance boost.

So, how big of a difference is there in the strides made concerning performance by athletes who use legal performance enhancing drugs and supplements versus those who do not use any supplements at all? This is a difficult question to answer because no two human bodies are the same. People react differently to different substances that they ingest, and no two people run on the exact same schedule for twenty-four hours a day, seven days a week. So, to provide the best possible answer, one must break down what a supplement is, what it is advertised to do, what somebody who is taking the supplement needs to do aside from regular consumption to receive the full effect as advertised, and of course, conclude what audience or demographic the supplement at hand will be most effective when being utilized. These supplements are never as

effective as one actually thinks, it is more about the lifestyle melding with the supplement to produce more effect results.

### **Creatine**

Adenosine triphosphate, or ATP, is the source of energy in the human body when looking at the biological composition of humans on a cellular level. The phosphagen system consists of the ATP and phosphocreatine storage. The ATP supply in the body is small and is sufficient to allow maximal effort or straining for no more than one to two seconds, but there are ways of providing more ATP to replace that being used during exercise. Muscles cannot obtain ATP from the blood or other tissues, so they must manufacture it. To do this, they need Adenosine diphosphate, or ADP, inorganic phosphate, and energy from other chemical sources to reconstruct the ATP molecules (Morton, 2008, p.2). One of these other chemical sources is creatine.

“Creatine is a nitrogenous organic compound found in muscle and is available in the diet through consumption of milk, red and white meat, fish, and mollusks, with meat and fish serving as the main supply” (Butts, 2017, p.1). This is how creatine is defined by MD Jessica Butts and DO Bret Jacobs of the National Center for Biotechnology Information. While all of that sounds nice, in laymen’s terms, creatine is a building block for proteins, which is what an amino acid is, but has been synthesized due to its ability to provide energy for major muscle groups in the body.

Creatine is naturally produced by the human body, and your muscles act as a storage unit for the creatine that is naturally produced. Once your muscles become tired, or strained, especially when lifting a weight, your body, or just the particular muscle in use to be precise, spends the creatine it had stored in order to maximize its efficiency in its movement. As stated above, the body’s natural ATP will allow for one to two second of maximum effort when moving

a weight, the rest of the energy spent in the muscle can be attributed to creatine. Creatine is reproduced rapidly once it is spent, and this is why most people after only thirty to sixty seconds are able to recover enough to complete an additional set in the weight room.

While creatine was first put into supplement form back in 1832 by a French scientist by the name of Chevreul, it did not become popular to start taking supplemental creatine until shortly after the 1992 Olympic Games in Barcelona, Spain. Supplemental creatine is now used worldwide among recreational, collegiate, and professional athletes, as it is considered to be one of the most popular dietary supplements available to the public consumer. The General Nutrition Company reported in their annual revenue report that they had a revenue of 2.06 billion dollars in their 2019 fiscal year. Creatine is responsible for about 15% of that annual revenue, which is much more than it seems at first glance considering the variety of products they offer in their stores.

While creatine use is common around the world among athletes, acquiring exact data is difficult as the data is limited to self-report surveys. However, the National Collegiate Athletic Association (NCAA) did conduct a voluntary survey among student athletes across the country about legal supplement use. In this study, 14% of all participating athletes admitted to taking creatine within the past 12 months. Meanwhile, the National Health Interview conducted a similar survey and reported that 34.1% of children and adolescents admitted to creatine use in hopes to improve their performance in athletics; this same organization also surveyed the military and reported that 27% of servicemen were users (Butts, 2017, p.3).

So, all these people are taking creatine, but do any of them use creatine effectively? Creatine dosing varies among the hundred, potentially thousands of different brands out there, which is why it is crucial to always read labels and put yourself in the best position possible to

see results. While many studies have reported positive feedback in their results regarding performance increases for athletes taking creatine, there are no firm guidelines regarding a supplementation regimen. Most creatine brands stay in the realm of one to five grams per day when trying to increase lean muscle mass in the body. In some studies, however, it does not appear that these outcomes were dose-dependent. Hall and Trojian (as cited in Butts, 2017, p.4) advise 0.3 grams per day as a maintenance dose, for 4 to 6 weeks on average, based on multiple reviewed studies. It is also essential to remember that most of these commercial brands intentionally provide vague instruction on the frequency of the dosing during the duration of the consumption period. None of these brands of creatine are regulated by the FDA.

Most people think that consuming creatine will result in muscle growth. That connection is true, but it is not a point A to point B line. As stated before, creatine is only an energy supplier, so by only taking creatine, you will not see any kind of results. In addition to taking creatine, one must make a habit out of religiously lifting weights, conditioning their muscles, as well as hydrating as much as possible (the recommended daily water intake is double your body weight in fluid ounces). If the consumer does not make a conscious effort in the gym concerning their reps, taking the creatine will all be for nothing. Translated, this means that since our muscles are given extra energy, doing the same number of reps at the same weight as usual will not result in any kind of significant growth concerning performance. Making the muscle-mind connection is the major key to visualizing muscle growth overtime when taking creatine. Consciously making the effort of bringing every set while lifting within the range of one to three repetitions until failure is the key to rapid muscle growth (Beardsley, 2020, p.2). So, taking creatine will be all for nothing if your gym habits do not change along with the consumption of creatine.

Creatine supplementation is meant to lean out the body composition, while simultaneously increasing the muscles in terms of mass, power, and strength in short-duration, high intensity exercises (Butts, 2017, p.4). While there is plenty of data that provides evidence to creatines effectiveness in the weight room or in a laboratory, there is little to none on game impact due to the lack of studies in that area. A meta-analysis done in 2015 verified that approximately 64% of participants who measured out their body mass and body composition before taking creatine experienced a significant increase in overall strength, as well as a significant decrease in body fat percentage over the span of three months. This group participated in an extensive resistant training program over the course of those three months, while the control group did not. The control group did have a percentage of individuals who experienced an increase in overall body mass, but it was not consistent with the decrease in body fat percentage. Approximately 18% reported increases in body mass (Branch, 2015, p.223). Overall, taking creatine in conjunction with an intense, and consistent workout program yields better results.

These changes in performance were independent from the age and sex of the participants. The study was focused more so on upper extremity response to creatine supplementation displaying the most significant strength increases, mainly at the pectoralis muscle. This is what most people would call their chest. The workout program was high intensity when it came to the bench press, showing improvements with an average of 5.3% increases in one repetition sets. These findings have been verified by other studies conducted elsewhere concerning improvements on the bench press (Branch, 2015, p.216).

However, one must proceed on their workout routine with great caution when taking creatine, because most people would consider riding a bicycle as a workout, which it is. With

that being said, creatine is not effective when combined with aerobic activities. These are activities that increase the heart rate with oxygen. Anaerobic activities, which are much shorter, higher intensity workouts, work the muscles without oxygen, which is when creatine comes into effect. Some anaerobic activities include lifting weights, circuit training, and sprinting.

Results have been a bit inconsistent overall in regards to athlete's response to taking creatine, but this may be for a number of factors. One might be that the athletes could be preloading on creatine. Athletes with a naturally high level of creatine in their body are far less likely to experience a change in performance as opposed to athletes with a naturally low level of creatine in their muscles. This is the most popular theory as to why 36% of athletes were non-responders in the experiments conducted.

Concerning the safety of taking creatine, there have been no side effects concerning short term usage of the supplement. The only short-term complication when taking creatine, one could possibly experience is dehydration, which is a warning on most labels anyways so it should never be an issue if the creatine has been taken as directed. Long-term however, there are theories that have been developed because of common experiences among creatine users. While these are only theories and have not been proven to be creatine related, those who answered these common symptoms in the survey all take creatine as the common relation. One theory is that creatine can lead to hepatic injuries, or trauma to the liver. The reason this is thought to be is because of, once again, dehydration. Without properly diluting the extra creatine you put in your system, you are asking our liver to perform tasks that is not used to performing. While there are many other theories that have been developed, this is the only theory that has a more than likely chance to be proven true one day (Butts, 2017, p.5).

To sum up creatine, it is a considerably safe supplement most to use without any serious side effects, and is completely legal according to the FDA, WADA, and NCAA. While the safety of creatine has not been studied in younger children, there would appear to be no effect on their development if they were to take it. When taken properly, creatine does have a higher chance to help you see improvements in performance than doing nothing for you. In reality, it all depends on the natural levels of creatine in the user's body. With higher levels, one probably would not be likely to experience a dramatic increase in muscle mass or strength. If there is one thing to take away from this section about creatine, make sure to stay hydrated when taking this supplement.

### **Stimulants**

Creatine is an energy supplier, but only for the muscles themselves. There are other supplements that supply that type of energy that gets you feeling wired or locked in; you feel like you can accomplish anything once you take it. These are known as stimulants. Stimulants often come with a negative stigma, since it is a word often thrown around only during drug awareness programs, rehabilitation, and other events associated with illegal drugs. There are many illegal stimulants, such as cocaine or methamphetamine, but there are many legal stimulants as well that average people consume on a regular basis.

The Alcohol and Drug Foundation (2021), defines a stimulant as “any kind of drug that speeds up the process of message transport between the body and the brain” (p.1). These drugs have the effect of blocking adenosine production within your body, which is a sleep promoting neurotransmitter. Consequently, somebody who is taking a stimulant is inclined to feel wide awake, alert, confident and energetic. The strength of these effect depends on a few factors, like the drug of choice, and the amount taken obviously. Some other factors that come into play here would be the overall size and health of the consumer, whether the consumer is used to taking the

drug or not, as stimulants are easy to build up a tolerance to, and if other drugs were taken at the same time.

If any of this sounds familiar to you, then you most likely regularly consume one of those common legal stimulants that most Americans take daily. More than likely, that stimulant is coffee, or more specifically, caffeine. Coffee is not the actual stimulant, which means coffee is not what is addictive, it is the caffeine in coffee that is addictive. Once this was realized, people started using caffeine in sports in hopes to increase their performance.

Numerous studies and experiments have been conducted on the effectiveness of caffeine supplementation on sports performance in which aerobic, anaerobic, or mixed programs have been prioritized. The most accepted dosage size for caffeine for one person is anywhere from three to six milligrams per kilogram of weight. To put this into perspective, a 200-pound man would need a minimum of 272 milligrams of caffeine to feel the effects, but no more than 544.2 milligrams. That gives the consumer a large range to choose from, making it a relatively safe drug (Mielgo-Ayuso, 2019, p.2).

Most people think that caffeine just serves a purpose to keep them awake, and while that is partly true, there is a little more to the science than that. Caffeine can affect the use of energy substrates during exercise. Specifically, it has been suggested that caffeine supplementation serves as a glycogen saver as it increases the mobilization of free fatty acids by adrenaline induction. Working conjunctively with that, caffeine also causes a spike in activity in the potassium and sodium within your body to amplify excitation contraction coupling (Mielgo-Ayuso, 2019, p.2). All of this basically means that in addition to stimulating the central nervous system and reducing fatigue, caffeine can improve endurance and increase muscular strength.

The FDA (2020) reported that 20 men who competed as sprinters of some sort were asked to run a total of ten 40-meter sprints. They ran ten one day, and the other ten days later; the first set of ten sprints acted as the baseline. For the second set of ten sprints, ten of the men were given 'an appropriate' amount of caffeine an hour before the sprints began, and the other ten were given a placebo, or a dummy drug. This way, nobody knew who received the caffeine. Those men who received caffeine were reported to lower their times on average by about one tenth of a second. Those who received the placebo, on average, lowered their times by two hundredths of a second, which is relatively no change at all.

Caffeine is not illegal. However, the NCAA considers caffeine to be illegal when there are caffeine concentrations found within the urine test of an athlete greater than 15 micrograms per milliliter (Courson, 2020, p.6). This is because caffeine does enhance performance, but also puts the athlete at risk for some negative side effects. Some of these side effects include fatigue, high blood pressure, rapid heart rate, muscle deterioration (only if caffeine is consumed in extreme amounts), and a lack of cerebral blood flow. These can all put the athlete at risk of injury, especially if they are participating in a high contact sport. This is the same reason that the NCAA test for marijuana among student athletes; it is more about injury prevention than the drug itself.

Another supplement that is considered a stimulant that is commonly abused by athletes is something called pre-workout. Pre-workout, as you can imagine, is always taken before the workout begins, approximately 15 to 30 minutes before to be exact. These supplements often come in powder form but can also come in the form of a pill, and their sole purpose is to energize the consumer for their workout. With the common athlete today always being in search

for a new method to enhance their training outcome, pre-workout has become the most popular stimulant out of all dietary supplements among athletes.

There is a common belief among scientists that substances such as caffeine, beta-alanine, L-citrulline, L-arginine, L-tyrosine, taurine and herb and botanical ingredients such as guarana extract, barley extract, cayenne pepper extract, black pepper extract and Huperzia serrata extract, which target different physiological mechanisms, may elicit synergistic effect. In turn improves athletic performance (Kaczka, 2020, p.3). This is essentially when two substances work together to create an effect or outcome that is much greater than if the substances were taken independently.

Many pre-workout brands share one common ingredient, which is caffeine. Some do not use caffeine, but that is rare and not a common method to supplementing pre-workout. As stated previously, caffeine has a positive effect on performance, more so on anaerobic activities as opposed to aerobic ones. Pre-workout takes that caffeine that already has the properties that allow the human body to reach new peaks during their exercises, and amplifies it with other ingredients, hence the synergistic effect.

One ingredient that is commonly combined with caffeine to create this synergistic effect is taurine, which is essentially an amino acid that increases base endurance levels and decreases lactate accumulation, or muscle fatigue (Miguel-Ayuso, 2019, p.2). However, with taurine alone, research results indicated that ingestion did not improve sprint times or total weight lifted in the bench press, despite a 16% increase in body fat oxidation (Kaczka, 2020, p.4). Not all pre-workouts use taurine to combine with caffeine though, some use ingredients like capsaicin, piperine, huperzia, and tyrosine. They all have different makeup but are generally aimed to do the same thing; reduce fatigue and increase ATP levels. Most pre-workouts use a different

method of arriving at the same destination. It should also be documented that pre-workout brands that are commercially available on most supplement stores' shelves also have a relatively large number of ingredients that do not have any kind of effect on performance.

The US National Library of Medicine found the effects of commercially available pre-workout supplements in both men and women weightlifters, by asking them to perform a three-repetition maximum test in the bench press lift five minutes after finishing an isokinetic strength test. The test was measuring peak torque in the bench press, rather than the total weight moved. Their warmup included a set of 12-15 repetitions on a standard Olympic barbell without any additional weight loaded on the bar. As the subjects completed one set of three repetitions, they were allotted two minutes of recovery time before beginning their next set.

The baseline was set days before, and the group of lifters were split up into two groups: one receiving a placebo, and the other receiving 'Total War' pre-workout supplement. On the day of the actual test, the placebo group increased their overall torque by about 10 Newton meters (from 200Nm up to 210Nm). On the other hand, the group that received the actual pre-workout saw their peak torque increase from 220Nm up to 240Nm, for a total increase of 20 Newton meters (Kaczka, 2020, p.7). Of course, torque does not necessarily translate to strength, but the observers of the test felt that testing for torque rather than strength would eliminate most sampling errors. Instead of having somebody who is much stronger than everybody else which could potentially skew the results, the baseline was set with torque so somebody moving a much heavier weight than somebody else may be moving that much heavier weight with the same amount of torque.

In conclusion, the tests performed and documented in this paper prove empirically that the supplement 'Total War' significantly improves total body strength and performance in

resistance trained athletes. Even with all the performance benefits one can experience with a pre-workout supplement, there is caution that needs to be taken as pre-workout can come with a multitude of negative side effects. Pre-workout has been known to cause vomiting, jitters, cramps, high blood pressure, and even send some users into cardiac arrest. Pre-workout can be the most dangerous of all legal supplements when not taken as directed.

Going back to the theme of young athletes not knowing the full list of consequences with the supplements they take, in 2014, an 18-year-old high school senior in LaGrange, Ohio died of cardiac arrhythmia, which is irregular heartbeat and a seizure. The young man's autopsy showed that his system had more than 70 micrograms of caffeine per milliliter of blood. Police authorities had found the very pre-workout supplement the boy was taking in his room, and concluded that in order to reach the caffeine levels that the young man died from, somebody of his stature would need to take about triple the amount of powder as compared to a normal, directed dosage. Meanwhile, the young man's mother claimed to have almost no knowledge of the supplement he was taking, or that he was even taking it to begin with. When asked if the boy had ever mentioned anything, he told his mother that the supplement 'was just like Gatorade' (CBS, 2014, p.1). This truly shows the dangers of being uninformed or naivety when it comes to supplementing in athletics.

However, none of those stimulants come close to the dangers that amphetamines. Oxford dictionary defines amphetamine as a synthetic, addictive, mood-altering drug, used illegally as a stimulant and legally as a prescription drug. Amphetamines became synthesized back in 1920. The drug was originally used to reduce fatigue and increase alertness during the World War II. Since then, there has been many derivatives that have been developed such as methamphetamine, also known as meth or crystal meth, dimethamphetamine, and methylenedioxymethamphetamine,

also known as ecstasy. All forms of amphetamines have been banned by the NCAA, all major American professional sports associations, and the International Olympic Committee. While none of those stimulants are commonly used in sports, there have been rare cases of athletes using amphetamines (ESPN, 2014, p.1).

Amphetamines, unlike their relative cocaine, are not readily broken down by the body's digestive system and are expelled through urine unchanged. However, the effects of amphetamines last much longer than those of cocaine. The most common effects of amphetamines include those of being wakeful, alert, a decreased sense of fatigue, mood elevation, increased self-confidence, and a decreased appetite. The effect of decreasing your appetite has been found to be very enticing among gymnasts, dancers, and wrestlers, as these sports put a huge emphasis on making weight for their competitions or losing weight to compete at a higher level (ESPN, 2014, p.1).

While they do create the same effects as caffeine, but much more powerful, amphetamines should never be in consideration for any athlete of any age. Amphetamines are highly addictive, and most people who become addicted to them eventually develop a fatal tolerance, meaning that if they do not take these illicit drugs, their body may shut down, and be forced to maintain itself with the help of life support. This high potential for tolerance and dependency have been proven through lab rats, as lab rats will self-administer the drug until they die once they have become hooked. "Tolerance to the mood-enhancing properties of amphetamines occurs after prolonged usage which, in turn, can lead to a pattern of increased dosing in an attempt to achieve the sought-after mood-enhancing effects," says Doctor Gary Wadler of WADA.

Amphetamine withdrawal is extreme. Those withdrawing from amphetamines may be subject to extreme fatigue, lethargy, and depression. While there is a raging debate on whether amphetamines are more destructive to the physical or mental health in humans, there is no debate that it has a major negative impact on both. Acute side effects include increased heart rate, increased blood pressure, insomnia, headaches, convulsions, or muscle contractions, hallucinations, paranoia, ruptured blood vessels in the brain, and heartbeat abnormalities and inconsistencies. The chronic side effects usually prove to be more fatal, even though many of the acute symptoms can cost a consumer their life. The chronic side effects include those like uncontrollable movements and muscle spasms of the face and jaw, compulsive and repetitive unnecessary behaviors, schizophrenia, blood vessel failure, and nerve damage (ESPN, 2014, p.3).

While many stimulants do pose to be very helpful in sports performance, there is a very thin line of what is legal and what is illegal. In addition to that, the physical risk reward ratio is not exactly one that is worth it. Caffeine is considered safe by most, but with the withdrawal symptoms that one can experience when taking it out of their daily diet, it raises a question of how close caffeine is related to amphetamines. Another question that could possibly be tested is can caffeine lead some people into using stronger stimulants, or in other words, can caffeine be a gateway drug. It is important to exercise caution when using stimulants. Stimulants do have a positive impact on some people's lives in the gym when taken in moderation, but it is so easy to let moderation run away from you when the drug is a highly addictive one; the most addictive drug in the U.S. at that. In fact, caffeine and stimulants are such addictive drugs that many supplement companies have pushed caffeine into many harmless supplements that have many health benefits without the addition of caffeine, like amino acid supplements for example. All in

all, stimulants do show signs of helping performance in short term, but the long-term effects that they can have on health may not be worth it, as some of them can be irreversible, or in some cases, leading to death.

### **Amino Acids**

Amino acids are a very popular supplement taken by many athletes, and this supplement is special because they directly link to protein; it is safe to say that everybody knows protein is the most important macronutrient when it comes to building muscle. Amino acids are the building blocks for protein in the human body, they also play many critical roles in the body like being responsible for building proteins and synthesizing hormones and neurotransmitters (Lopez, 2021, p.5). As a building block, when a muscle has been broken down from lifting weights it functions to repair the muscles. This occurs when the weightlifter consumes their protein after the workout, as the body will break down that protein rapidly, and it is broken down into amino acids. Those amino acids will then be used to repair and grow new and stronger muscle fibers.

Amino acids deliver a different result from protein when taken separately. While protein boosts the total protein consumption and contributes to calories, it is more of a filler for the gaps in an everyday diet. On the other hand, amino acids pinpoint specific and diverse areas of the metabolism. One amino acid may affect brain chemicals, while another may contribute to muscle performance (Cole, 2018, p.1). All of these amino acids contain oxygen, carbon, hydrogen, and nitrogen.

Amino acids have been around for over two centuries now, as the first recognized amino acid was isolated in 1819. That amino acid was leucine ( $C_6H_{13}NO_2$ ). While asparagine was isolated in 1809, its role as a constituent of protein was not recognized until 1873 (Martz, 2002, p.1). While it is not known exactly when amino acids were put into supplement form, athletes

have been using them for the last half century. It is believed that amino acids do more than just help with the regrowth of muscle fibers, as most scientists would tell you they also increase the secretion of anabolic hormones, modify fuel use during workouts, help prevent injuries due to overtraining, and help prevent mental fatigue (Williams, 2005, p.3).

With having virtually no downside to taking amino acids as a supplement as long as you hydrate properly while taking them, amino acids are a great supplement to take your workouts, muscle growth, and muscle recovery to a new level. The key to taking amino acids is knowing which ones to take. Although there are hundreds of amino acids in nature, humans only need 20 to make up all proteins found in their body. This applies for most forms of life. These 20 amino acids are all L-isomer, alpha amino acids. “It is also worth mentioning that the amino acids selenocysteine and pyrrolysine are considered the 21st and 22nd amino acids, respectively. They are more recently discovered amino acids that may become incorporated into protein chains during ribosomal protein synthesis. Pyrrolysine has functionality in life; however, humans do not use pyrrolysine in protein synthesis. Once translated, these 22 amino acids may also be modified via a post-translational modification to add further diversity in generating proteins” (Lopez, 2021, p.3).

These 20 amino acids can be broken down into three categories: essential amino acids, conditional amino acids, and nonessential amino acids. Speaking to the essential amino acids, these cannot be produced autonomously by the human body. These are the amino acids that must be obtained through your diet. The best sources to obtain these essential amino acids is in animal proteins like red meat, eggs, and poultry. To be exact, there are nine essential amino acids, and each one of them play a different role in maintaining the body’s daily functions (Kubala, 2018, p.3). When talking about nutrition, the nine essential amino acids are obtainable by a single,

complete protein, which are usually in animal-based foods except for soy. However, the essentials are also obtainable through incomplete proteins, which are usually plant-based foods (Lopez, 2021, p.4).

The first essential amino acid is phenylalanine and it acts as a forerunner for neurotransmitters such as tyrosine, dopamine, epinephrine, and norepinephrine. Phenylalanine can be found in an L form and a D form. The L form of this amino acid is the one that is found in food. The D form is what has been synthesized by scientists to be used for specific medical conditions. These two forms are basically identical, aside from a minor mutation found in the D form's molecular structure. What makes phenylalanine 'the first' essential amino acid is its ability to contribute to the production of other amino acids. Phenylalanine also plays a vital role in forming the basic structure of muscle tissue and enzymes (Kubala, 2018, p.2).

The second essential amino acid is valine, and it is one of three branched-chain amino acids. This means that it has a chain branching off to one side of its molecular structure. Valine is primarily involved with muscle stimulation and regeneration, but also is crucial in producing energy for the body. Like Phenylalanine, valine also has an L and D form, and they are classified as such for the same reason as well (Kubala, 2018, p.2).

Valine is closely related to leucine, as leucine is the second branched-chain amino acid, and plays a similar role in muscle stimulation and regeneration. Leucine does have qualities that separates itself from valine. One of these qualities is how leucine helps regulates blood sugar levels like insulin. Leucine also contributes to external and internal wound healing. This is because leucine is the main producer of growth hormones among all amino acids (Kabala, 2018, p.2).

The last of the three branched-chain amino acids is isoleucine; its main contribution to the body is its involvement with muscle metabolism. Isoleucine is also one of the most heavily concentrated amino acids found in muscle tissue. When looking to build muscle and taking amino acid supplements, looking for an amino acid supplement that contains isoleucine would be a good start. Isoleucine also comes with benefits in immune support, energy supply, and hemoglobin production (Kabala, 2018, p.2).

The fifth essential amino acid would be threonine. While this amino acid does not play a role in muscle development, as the proteins it helps form are more for the epidermis and its connective tissue, threonine is a great amino acid to take when looking to get into shape. Threonine has a metabolism boosting quality that helps people use their calories more efficiently. That is in addition to the immune support it also offers (Kabala, 2018, p.3).

Sixth on the list of essential amino acids is tryptophan. There is a bit of a downside to tryptophan, but it seems so minimal when taking all of the benefits it offers into account. Tryptophan has been known to cause drowsiness, which is thought to be the reasoning as to why most supplement companies add an unnecessary amount of caffeine to their amino acid supplements. Despite the drowsiness one might feel when processing tryptophan, one would be rewarded with a proper nitrogen balance, which basically means that their body will synthesize protein more efficiently, as well as experience a proper hormone balance. Tryptophan is also a forerunner to serotonin, which is a neurotransmitter that assists with regulating appetite, sleep, and overall mood (Kabala, 2018, p.3).

The seventh essential amino acid is an interesting one, mostly because it also serves as an antioxidant. This amino acid is methionine, and it plays a critical role in the body's ability to detoxify itself. With methionine being an antioxidant, it may help protect the body from damage

caused by various forms of radiation. In addition to that, methionine may detoxify harmful substances in the body, such as heavy metals. Methionine also looks out for the liver, as it has been known to prevent liver damage from acetaminophen poisoning and fat deposits. Methionine is also necessary for the absorption of zinc and selenium, which are vital minerals that everybody should try to take daily (Kabala, 2018, p.3).

Eighth on this list of essential amino acids is lysine. Along with protein synthesis, lysine's main role in the body is to produce sufficient enzymes and hormones. This means that lysine is essential in the earlier years of growth for humans. Lysine also is a great energy supplier, as it is responsible for the conversion of fatty acids into energy, which helps lower low-density lipoprotein, or bad cholesterol. Lysine is also excellent for calcium absorption, as well as collagen and elastin formation. These are the main proteins found in connective tissues in the epidermis, muscle tendons, and cartilage. Consequently, lysine is great for joint health (Mount Sinai Health, 2021, p.1).

Finally, the last amino acid that the human body cannot produce autonomously is histidine. Histidine is great for nerve cell protection, as well as repairing damaged muscle tissue. Histidine is responsible for the production of histamine, which is a neurotransmitter that is vital to immune response, digestion, circadian rhythm, and sexual function. With its ability to protect nerve cells, especially in the epidermis, doctors have been known to prescribe supplemental histidine to patients who experience severe eczema (Kabala, 2018, p.4). This amino acid is probably the least beneficial to athletes in terms of muscle growth and performance enhancement.

Amino acids provide athletes with a plethora of benefits, and the timing of amino acid supplementation has a huge impact of the specific results one can expect when taking them. For

example, many strong man competitors who take amino acids say that when they are looking to go through a cutting phase, meaning they want to drop their body fat percentage and overall weight, they will transition from taking their amino acid supplement from either during or directly after their workout, to approximately 15 minutes before their workout. This allows the athletes to train on an empty stomach without feeling nauseous or faint, as the amino acids provide energy and also give the stomach some kind of matter to metabolize for the next hour or so. By consuming amino acids before a workout, you allow the amino acids to increase your body's anabolic rate, which is essentially how fast the body response to rebuilding muscle after exercise competition. If this timing for amino acids is going to be utilized, one should be aware that the weight loss would be more effective if the workout is occurring in the morning, as opposed to the afternoon or evening.

By taking amino acids after a workout, you are asking the amino acids to respond more like a protein would in terms of packing on muscle. The amino acids are much more easily digested and absorbed by the body than a protein supplement though, meaning that the aminos would act much faster to build new muscle fibers than the protein itself would. However, that does not mean amino acids can serve as a substitute for post-workout protein consumption. Amino acids on their own will not be able to supply the body with a proper daily protein consumption, and they may also cause the body's metabolism to become disrupted and irregular.

All in all, amino acid supplementation is harmless as long as they are consumed in proper quantities. The only real side effect from taking too many amino acids is an unbalanced metabolism. Amino acids should be seen as a vital nutrient, much like protein, carbohydrates, and lipids. The fact that there are nine amino acids that humans need to live a healthy lifestyle

and cannot be obtained through diet should be enough motivation for anybody who is on the fence about taking supplemental amino acids to go out and buy some.

The key to buying the right brand is to study up on what specific amino acids do or the body, decide which of those amino acids and their benefits speaks the loudest to you and will help outreach your personal fitness or health goals, and carefully read the labels of different brands to see what specific amino acids the brand puts into their supplement. Many brands differ, so it is crucial to read labels before you buy amino acids. After deciding what amino acids are the right choice for you, always remember that just because they help with muscle stimulation, growth, and repair, that there is never a reason to use amino acids as a substitute for protein consumption. This can lead to malnutrition, muscle decay, bone decay, and an array of other preventable health issues.

### **Protein**

Amino acids cannot serve as a substitute for protein, but what is protein precisely? According to the U.S. National Library of Medicine (2021), proteins are complex molecules that play many critical roles in the body. They do most of the work in cells and are necessary for the overall structure, function, and regulation of the body's tissue and organs (p.1). Proteins are made up of amino acids, and the sequence of those amino acids is what determines each protein's specific function. There are many functions that proteins can perform, including balancing hormone, acid-base, and fluid-electrolyte levels. Proteins also act as a transporter for nutrients throughout the body, and they make up the antibodies that strengthen the immune system (USLM, 2021, p.2). However, none of those roles is as enticing to athletes as the role protein plays in muscle growth.

The human body has a daily requirement for protein, as protein is a macronutrient much like carbohydrates and fats. All those macronutrients serve a different purpose in the body's ability to function on a day-to-day basis. With that being said, protein is needed to strengthen skeletal and muscle tissue, as well as strengthen the immune system, and those are two benefits that entice athletes to take supplemental protein in hopes to enhance the strengthening of the skeletal and muscle tissue that their body already naturally provides.

The current recommended dietary allowance for protein for a normal human being, or a non-athlete who exercises solely just to maintain a healthy lifestyle, is 0.8 grams per kilogram of body weight per day. To put that into perspective, a man who weighs 190 pounds should be consuming approximately 69 grams of protein each day (Grosvenor, 2021, p.158). However, athletes require much more protein as they make a living out of tearing and rebuilding muscle fibers every day in an effort to become stronger than everyone else. Consequently, athletes need a much larger protein intake. The recommended protein intake for an athlete is roughly double the amount that a normal person should be consuming daily. This is why protein was made into a supplement; it gives athletes a quicker, easier way to ingest protein, especially after a workout.

Hypothetically speaking, if there was a college football player who weighed 250 pounds, he would need to consume anywhere between 158 grams to 181 grams of protein per day to maintain proper health. That is the equivalent of eating at minimum 26 hardboiled eggs, or 40 avocados, or even four whole chicken breasts. Not too many people have the stomach room for that much food, and that is where protein supplementation comes in handy. By drinking supplemental protein, you allow your body to get a large serving of protein without asking it to process too much chyme at once. Protein supplementation cannot serve as a meal replacement though, as most protein supplements only provide the macronutrients in a diet, which is the

protein, carbohydrates, and lipids. Protein supplements do not supply the body with the micronutrients, which are simply just vitamins and minerals that the body relies on for energy and overall immune health.

In 2015, dietary protein supplement sales were at their highest ever, with 4.7 billion dollars in sales revenue across the nation (Cintineo, 2018, p.1). The General Nutrition Company reported that the age group that the majority of protein supplements are sold to are men between the ages of 16 and 24. The popularity of protein supplements for younger men most likely comes from the influence of older, professional, athletes who promote these supplements on their social media pages, saying that by taking the supplement you can take your game to the next level. Before taking a protein supplement, an athlete should ask themselves a number of questions that are often overlooked because protein is relatively safe since it is a macronutrient.

One question that should be answered first before purchasing a protein supplement is, ‘what protein is right for me?’ You can get different kinds of proteins from plants and animals, and all of variations of plant and animal-based proteins have been supplemented. Athletes tend to favor the animal-based proteins as they support human muscles more fittingly than the plant-based ones. That is not to take away from the benefits of plant-based proteins, especially since they are so beneficial to vegetarians and vegans who struggle to meet their daily protein needs.

Soy protein is the most popular plant-based protein, mostly because it does not lack in any of the essential amino acids, and it has also been proven to come along with health benefits like lowering your risk for breast cancer, heart disease, and osteoporosis. Despite most people’s beliefs about soy protein, it does not lower testosterone levels, or even raise estrogen levels, so increasing muscle mass should not be a problem while taking soy protein. However, soy protein

is not effective when it comes to overall weight gain, so if you are looking to gain weight while putting on muscle, then soy protein may not be for you (Messina, 2020, p.2).

Another subtype of plant-based protein is pea protein. Pea protein has the same absorption time as soy, and has similar health benefits especially when it comes to fighting heart disease since after all, it does all come from a green vegetable. Pea protein is great for obtaining the nine essential amino acids that your body cannot create on its own, but pea protein is low in supplying methionine. However, the main component that separates pea protein from others is its richness in iron. Iron deficiencies are tough to combat with, so drinking pea protein after the gym may help with that uphill battle (Messina, 2020, p.4).

Rice protein is unpopular when considering all factors. While it is easily digested and hypo-allergenic, it is lacking in the amino acids department; falling short in lysine. However, rice protein is good for balancing blood sugar levels (Messina, 2020, p.4).

The final plant subtype protein mentioned was hemp protein. Hemp protein is derived from hemp seeds and is known for containing high levels of fiber, as well as omega-3 and omega-6 fats, which are usually recommended to take in a multivitamin. This is a good, natural substitute for taking in those essential fats. With that being said, hemp protein is also unpopular mostly because it also lacks in the amino acids lysine just like rice protein does (Messina, 2020, p.4).

To reiterate, plant-based protein supplementation is not a popular choice for athletes, as it may not provide athletes with the surplus of protein that they may be looking for. When trying to increase performance levels in whatever sport the athlete may play, the common supplemental choice among athletes is whey protein. Whey protein is primarily the protein found in dairy, as whey is a byproduct of the cheese making process (Mayo Clinic, 2020, p.1). Whey protein also

provides ample amounts of the essential amino acids, and is also much denser in protein itself than plant-based sources. When whey protein is taken as a supplement, it is usually in powder form, and is recommended to be diluted with water, or even milk, and drunk as a smoothie or milkshake. The recommended time to consume supplemental whey protein for athletes is right after a workout, preferably during the athlete's anabolic phase, that way their body metabolizes the large sum of protein more efficiently.

Cintineo (2018) examined whey protein, concerning its true effect on performance. The main finding from the long-term observation made by the group of researchers was that the outcome of taking supplemental whey protein is almost completely dependent on the consumer's total daily protein intake, in addition to the total caloric intake. While there was plenty of evidence that supports the claim that whey protein supplementation can aid with the addition of fat free mass on an athlete, there was little to no evidence at all that supported the claim that athletes who take supplemental whey protein and already meet their daily protein needs through their diet will experience an increase in muscular strength (Cintineo, 2018, p.2). This may give somebody the idea that taking whey protein is pointless if they can just reach their daily protein goal through their diet. For somebody who is not looking to put on weight that may be the case, but the findings stated above only remain true when speaking in terms of strength related to body weight. The athletes who put on the fat free mass did not get stronger in terms of lifting a higher percentage of their body weight than before, but it did remain the same. So as their body weight went up, so did their one repetition maximum on the bench press. Technically speaking, the athletes did get stronger, it just came with the addition of fat free mass as well. May it be known that the fat free mass did not hinder any performance levels aerobically. The athletes were still

able to run just as fast as they could at the start of the experiment and could hold isometric exercise positions (like a body-weight plank) for a longer period than they could before.

Researchers for the National Center for Biotechnology Information discovered that whey protein can facilitate muscle recovery following an intense isotonic exercise bout, meaning that whey protein may serve more than just as a caloric replacement supplement. The whey protein drink, which contained 25 grams of protein, 2.5 grams of fat, and 3.5 carbohydrates, was matched up with a popular sports drink that advertises itself as a recovery specialty, and was composed of no protein, no fat, and 36 carbohydrates. A fair beneficial effect on anaerobic strength and power was found in the group that consumed the protein supplement, which suggests that there may have been improvements in rate of recovery over those who consumed the carbohydrate drink. This is shocking given the reason that the subjects were already habitually consuming their 1.9 grams per kilogram per day of protein and may hold some kind of relevance for athletes engaging in high-intensity, explosive sports like football or hockey (Cintineo, 2018, p.7).

With all of these findings, it may seem that whey protein has no real downside. Despite the many health benefits that whey protein can provide a person, there have been claims to whey protein supplementation being dangerous. The large sum of protein at once has been thought to cause damage to the kidneys and liver, may possibly be a factor those who suffer from osteoporosis. Whey protein has also been known to cause some people major trauma concerning digestion, as these individuals have experienced bloating, gas, stomach cramps, and diarrhea. The majority of these patients who experienced these side effects also reported to be lactose intolerant, which follows as whey protein is found in dairy. However, the side effects were reportedly much worse than if the patient had just eaten cheese or drank milk. For people who

suffer from lactose intolerance, there is an isolate variation of the protein powder, which extracts lactose from the whey protein (Raman, 2017, p.3).

Another protein supplement often taken by young athletes in an effort to rapidly improve performance is mass gainer, and it is advertised to do exactly what the name says. Mass gainer is still a protein supplement, which means it can use plant-based or animal-based proteins, but mass gainers are also rich in carbohydrates. Like a normal protein supplement, mass gainers are providers for macronutrients, so they work hand in hand with an athlete's daily calorie count. Most mass gainer brands serving sizes add up to somewhere between 800 and 1200 calories (DrugResearch, 2021, p.1).

On the contrary to protein isolate supplements, mass gainers are more so used for people who need to gain weight, and or have trouble reaching their daily calorie goals. As previously stated, mass gainers are also rich in carbohydrates and sometimes fats, so they essentially serve the body as a whole meal. People who struggle to simply eat their calories may use mass gainers to consume their remaining calories as it does not take up the same amount of space in their stomachs as a full meal would. On average, a serving of the typical mass gainer product contains carbs and proteins in the proportion of 3:1 favoring the carbohydrates (DrugResearch, 2021, p.1). This balance is used to provide those taking it with the nutrients required for building muscle, but also replenishing glucose levels, which is the body's main source of energy.

Researchers for the Nation Center for Biotechnology Information also found interesting results based on mass gainer enhancing effects on strength. Mass gainers work the same as protein when it comes to building muscle, since they are just a protein-carbohydrate combination. When athletes performed their bench press 3 months after the starting point in the experiment, the men in the experiment showcased that their lifts increased consistently with their

body weight, and also put on an average of 94% fat free mass. The women on the other hand did not output the same results. The women in the experiment showed an average of a 15% decrease of strength relative to their body weight while taking the mass gainer. The women also demonstrated that they are more likely to put on body fat than fat free mass when taking mass gainer due to the surplus of carbohydrates, as the women on average put on 48% fat free mass. These percentages ended up being approximately an average of 1.6% increase in body fat in men, and almost 7% increase in women (Cintineo, 2018, p.9). To put those numbers into perspective, the line for obesity in women sits at 32% body fat. A female athlete typically should have no more than 20% body fat, and the average woman would be somewhere between 25% and 31% (Marsden, 2012, p.3). If a female athlete who is sitting at 20% took part of this experiment, by then end she would have only been about 5% shy of being considered obese.

In contrast to the women, the men handled the mass gainer relatively well. While there was no real increase in strength, there was not a loss in strength either. As the men put on mass, they also were able to add weight to their bench press. Male athletes are supposed to have no more than 13% body fat, that is unless the sport normalizes high body weight like football. An obese man would be considered to have a body fat percentage anywhere north of 25%, and the men in this experiment only increased their body fat by an average of 1.6%. Even the most 'unfit' male athlete would still be more than 10% shy of the obesity line after the three months of regular mass gainer consumption (Marsden, 2012, p.3).

Overall, protein intake in supplement form plays a more critical role from a dietary standpoint and meeting macronutrient and caloric goals, rather than actually packing on muscle. Protein does assist with getting stronger in terms of being able to move more weight, but it does come with the addition of body weight as well. Whether that is fat free mass or body fat mass

really solely depends on the rigor of the workout program the athlete is executing. Eating a surplus of protein right after a workout gives your body one of two choices. If your body is drained of macronutrients from the workout because of the intensity, your body is much more likely to take the surplus of protein and store it in the muscles and pack it on as muscle mass because of the body feeling the need to replenish the lost nutrients as fast as possible. The other option is to store the excess protein as body fat. This occurs when the body is given far too much protein to store in the muscles, as not enough has been lost, or it is simply not desired, and the body has no choice other than to store it as unused energy, or fat. Supplemental protein can be beneficial to young athletes if they are educated on what excess protein can do for them, the risks of consuming too much, and being clear and concise with their fitness goals.

Men clearly have a distinct advantage when it comes to protein supplementation. The natural body composition between men and women varies to a significant degree. Genetically, men have much more lean mass whereas women have more body fat. Women are much more likely to store protein supplement as fat, compared to men who are more likely to store it as muscle. Reiterating, the use of protein almost entirely depends on the intensity of the workout, but women have far less room for wiggle than men do. Men tend to respond to a protein surplus by adding on fat free mass while simultaneously vigorously working out, while women tend to put on more body fat. However, there is nothing wrong taking a protein supplement as a replacement for the protein you cannot consume through your diet, but it should not serve as a whole meal replacement. Protein supplements may be able to give you protein, but unless they are mass gainers, they cannot supply you with the proper carbohydrates and fats. It is also important to remember that no protein supplement can replace the micronutrients needed in a

diet, so it is safer to eat a meal and take a protein supplement after working out if you decide to use supplemental protein.

### **Nitrate**

Nitric oxide is a molecule that is produced autonomously by the human body and is used in many ways to maintain health. Nitric oxide is the main contributor to vasodilation, which is essentially how the body increases blood circulation when it is deprived of oxygen. This is a process that most commonly happens when the body is forced to strain, or exercise. Nitric oxide has the ability to force the muscles that are deprived of oxygen to relax, giving more room to the blood vessels in the area, widening those blood vessels, and increasing circulation. This is the feeling that weightlifters would call 'the pump' (Walle, 2018, p.1).

Nitric oxide production is essential for overall health as well as it allows nutrients, blood, and oxygen to travel to every corner of the human body. Some people suffer from a deficiency of nitric oxide, which is what leads them to diabetes, heart disease, and possibly erectile dysfunction (Walle, 2018, p.1). These deficiencies are what led to the creation of supplemental nitrate. There are many ways to increase natural nitric oxide levels, like eating vegetables that are high in nitrate such as spinach, celery, and lettuce, or increasing antioxidant consumption of Vitamin C, Vitamin E, and glutathione, but sometimes people who use the natural methods still fall short of their nitric oxide needs (Walle, 2018, p.2).

Dietary nitrate has been growing in popularity for this very reason. With the other benefits that it comes with, it has obtained the attention from athletes who may not even suffer from a nitric oxide deficiency as well. Nitrate and nitric oxide are related in this world of human dependency, but they still have their differences that should be clarified. Nitric oxide is a simplified form of nitrate, as nitric oxide is one nitrous molecule that has formed a bond with an

oxygen molecule, whereas nitrate is still one nitrous molecule, but the bond has been formed with three oxygen molecules, giving it the chemical formula of  $\text{NO}_3^-$  (Weitzberg, 2010, p.4).

By consuming any form of nitrate, the body will then convert it to nitric oxide, which is why nitrate supplements were created to help with nitric oxide deficiencies. These inorganic forms of nitrate have been proven to enhance athletic performance and endurance. This is because dietary nitrate, which often comes in the form of a pill, creates an ergogenic effect due to the mitochondrial oxygen efficiency through a reduction in the oxygen cost of exercise that increases vasodilation and blood flow to the skeletal muscle in recreationally active athletes (Lorenzo Calvo, 2020, p.1).

Since blood is responsible for transporting oxygen to all parts of the body, including the muscles, the main claimed effect from taking a nitrate supplement is that they will assist with the longevity of exercise duration while simultaneously cutting down the time needed for recovery in between sets. Body builders have also been known to utilize nitrate supplements right before competitions because nitrate supplements aid with visual benefits. Due to the increased blood flow, the 'pump' that people experience when working out become visually evident when taking nitrate. Basically, nitrate supplements make a person appear to be much more defined and vascular than they really are (Lorenzo Calvo, 2020, p.3).

Researchers from the National Library of Medicine found results that speak to the effects of nitrate on athletic performance. A large group of randomly selected athletes, both male and female, between the ages of 21 and 28 were brought in, and were randomly split up into two groups; one being the control group, and the other being the test group. The control group was given a placebo to take before working out, and the test group was given the proper nitrate supplement dosage 15 minutes before beginning the workout. The workout consisted of a

dynamic warmup, two warmup sets on the bench press, and three, three repetition maximum sets on the bench press.

The control group went first to establish their baseline. The control group baseline averaged out to have a three-repetition maximum of 199 pounds on the first set, 198 pounds on the second set, and 189 pounds on the third set. The group was given a two-minute rest period in between each set. This averaged out to be five pound drop off per set due to fatigue. Meanwhile, the baseline set for the test group averaged a three-repetition maximum of 194 pounds on their first set, 190 pounds on their second set, and 180 pounds on their third set, which averages out to be a seven pound drop off in between each set. With only a difference of 8 pounds in the first group, and a difference of six pounds in the second group concerning their two drop offs, this eliminated the possibility of selection errors between the groups. There could not be an excuse or explanation as to why one group performed better than the other in the experiment based on a claim that one group was simply stronger than the other (Lorenzo Calvo, 2020, p.7).

On the measurable day, the same test was performed to see how the nitrate improved performance, except this time, the recovery time allotted was brought down from 120 seconds to 100 seconds. The control group went first once again and averaged the same starting weight as they did on their baseline (199 pounds). 120 seconds later, they dropped off to 195 pounds, which was three pounds more than what their baseline indicated. For their third and final set, they averaged a total of 183 pounds, which was an additional drop off of 12 pounds. This was a three-pound difference from their original drop off in this set. These differences in the control group were expected as the recovery time was shortened from the first experiment. These same differences were not expected to be as evident in the test group, as the main component being

tested in the experiment as the increases in recovery efficiency that nitrate supplements can provide an athlete (Lorenzo Calvo, 2020, p.7).

The test group went second, 15 minutes after their nitrate supplement was taken. Their first set was still 194 pounds, but their second set dropped just one pound, as opposed to their baseline test, when their first drop off was four pounds. Their third and final set they fell to 185 pounds, for another eight pound drop off. This eight-pound drop off is compared to a ten pound drop off from their baseline test, in which they had a longer recovery time for. So, not only did the recovery time shorten in the second test, the test group was able to decrease the amount of drop off in between their three-repetition maximum on the bench press (Lorenzo Calvo, 2020, p.7).

In the experiment, statistics showed that the nitrate supplement did help with recovery in the weight room. The control group posted an overall ten pound drop off in their first test, and a 16 pound drop off in their second test. Keeping the lost minute of total recovery time from the day of the first test to the day of the second test makes the six-pound difference fathomable. On the other hand, the test group posted a total drop off of 14 pounds on day one and cut it down to only nine pounds on the second day of testing. This supports the claim that nitrate supplements have the ability to cut down needed recovery time in an athlete's workout.

There are anomalies that exist, and the experiment could be proven to have some major flaws in it, so nobody can say with 100% confidence that the experiment proved that supplemental nitrate is 100% effective. One factor that could have played into the experiment is the natural stamina levels of the test subjects. If the athletes were selected randomly, then these athletes could be training in different styles for their different sports year-round. An Olympic weightlifter does not train the same way that a basketball player would, as the basketball player

would prove to be much weaker when it comes to one repetition maximum lifts, or any Olympic lift for that matter. However, the basketball player may have much better control of their cardiovascular recovery, meaning they could complete multiple sets with 100% of their power when an Olympic weightlifter may only be able to complete one or two since that is all they train for. The experiment did not take body weight into account either.

While the total weight lifted did not have a dramatic change or difference between the two groups, the experiment did not specify the test subjects body weight. The dosage size did not say that it was relevant to body weight due to the supplement being in the form of a capsule, which means that there could have been extreme outliers in the experiment had one of the subjects weighed significantly more or less than the others. It was presumed that the men all weighed relatively the same as each other, same for the women, but it was never stated directly.

So, while the evidence points to nitrate supplements being 100% effective, there are still too many unanswered questions to say that statement is a fact. People have different reactions to nitrate and have different levels, as no two bodies are built the exact same. There was no control over the test subjects' diets, which means that some lifters may have been taking additional nitrate without even knowing it during the experiment. Many foods that people consume regularly have a side effect of increasing natural nitric oxide levels within the body. Some of these foods include certain kinds of shellfish, citrus fruits, dark chocolate, and leafy greens. These are just a few of the foods that naturally raise nitric oxide levels within the body, so had the subjects consumed any food that is known for that side effect, they may have been likely hindering their chance for accurate results in the experiment (Lorenzo Calvo, 2020, p.8).

Another possible variable to the nitrate supplement experiment is the amount of sleep the test subjects were acquiring every night before the tests. The commonly recommended hours of

sleep an individual should be getting on a nightly basis is eight hours. This is because it allows an individual to acquire around 90 minutes of rapid eye movement (REM) sleep. In a separate test on rats monitored by the Shanghai Health Bureau, it was proven that REM sleep deprivation can also impair nitric oxide levels within the body (Gan, 2017, p.3). REM sleep occurs in cycles that vary in length; the first cycle does not typically occur until the person has been asleep for approximately 90 minutes. The first cycle is usually about ten minutes, and each cycle after gets longer than the last. Without REM sleep, the brain is not stimulated to produce certain hormones that assist with energy production, or chemicals such as nitric oxide, that assist with blood flow (Gan, 2017, p.5). Subjects who did not acquire the necessary amount of REM sleep could have also hindered the results of the experiment.

To conclude, nitrate supplements have been tested extensively and have evidence that supports their claim to increase blood flow in the body, especially to the muscles, and assist with the muscle stamina during exercise. However, this should not be the first stopping point for athletes who are looking to up their performance levels in a hurry. Nitrate supplements have not been tested in terms of their help with long term results, meaning there is a possibility that the human body could build up a physical dependency on them if they are used consistently for every workout. While these supplements are not banned by the NCAA or any other athletic association, it may be a safer decision to just use natural remedies to help boost nitric oxide levels within the body. Some users of nitrate supplements have gone too far with the dosage sizes and have suffered from methemoglobinemia. This disease is known for turning the epidermis a blue-purple color which results in serious illness or even death (Minnesota Department of Health, 2009, p.5).

Considering the risk reward when it comes to nitrate supplements, it is much safer and more efficient to go with a different supplement to assist with stamina and energy like creatine or caffeine, mostly because nitrate supplements do not affect everyone in the same manner that creatine or caffeine does. With all the other factors that come into play when trying to make nitrate supplementation effective, there may be too much to try and monitor while taking the supplement, as opposed to just taking a recommended dose of creatine instead.

### **Anabolic Steroids**

In a perfect world where everybody was a law-abiding citizen, outlawing a product would mean that nobody would use it. Unfortunately, that perfect world does not exist, and people use and abuse anabolic steroids regularly, despite being fully aware of the dangers they put themselves at risk for when abusing them. Young athletes have this notion that since a relatively small percentage of professional athletes, that it is ok to use them their selves since the professionals often do not face consequences when abusing anabolic steroids. In a survey conducted in 2020 by the National Center for Biotechnology Information, only 15% of all former collegiate athletes interviewed admitted to using anabolic steroids at some point in their careers. Likewise, 12% of professional football, basketball, and baseball players admitted to the same offense. However, about 20% of high school athletes answered yes to using anabolic steroids at some point. Whether this was a repeating cycle for the athlete or just a one-time offense was not shared (Lewis, 2020). High school athletes may potentially turn to anabolic steroids because they feel they cannot overcome the plateau in the weight and look up certain body builders online to copy their exercise routine, as well as their dietary lifestyle. This is a mistake because 80% of competitive body builders in the same survey admitted to using anabolic steroids at least once in their professional career (Lewis, 2020).

Anabolic steroids are nothing more than a synthetic derivative of the male sex hormone testosterone. Aside from its main function as the sex hormone in males, testosterone is responsible for overall muscle mass, fat distribution, and red blood cell count. This is the reason that men are physically stronger than women in the weight room (Lewis, 2020, p.6). This is also the reason that steroids were made to copy the effects of testosterone. While there are few instances where anabolic steroids are legal to use, there are virtually illegal everywhere. Not only do they run the integrity of fair competition, but they also put the user at risk for long term health problems.

What is so enticing about anabolic steroids is that their ability to increase muscle mass and cut down body fat percentage can be seen clearly within three weeks of the first dosage (Lewis, 2020, p.5). Three weeks is such a short amount of time when talking about completely reconstructing somebody's body composition. A person who is not using anabolic steroids but is also trying to reconstruct their body composition will not tend to see any kind of results until about the sixth week, and they will not be nearly as visible as they would be at the third week with anabolic steroids. In today's world everything is all about convenience. Humans have this knack about them that they always find the easiest way to complete a task. Anabolic steroids have proven that they are the easiest way to build muscle with as little work as possible.

Even somebody who does not exercise at all while taking anabolic steroids is inclined to become bigger, faster, and stronger. Scientists for the Nation Center for Biotechnology Information did some research based on how athletes who take anabolic steroids and do not work compare to athletes who do not take anabolic steroids and do workout. The experiment was conducted twice. Once with a group of women, and again with a group of men. All the test subjects were athletes who were randomly selected. By selecting all athletes, this eliminates the

possibility of a substantial baseline error. The baseline error could have occurred if somebody who was not an athlete, or somebody who had never lifted weights took part in the experiment. This would be an issue mostly because somebody who has no experience in the athletic field would be likely to make much larger strides than an athlete would when taking anabolic steroids. This is simply due to the threshold theory, where an athlete only has a certain amount of body mass they can healthily sustain before collapsing in on themselves. An athlete is much closer to their body mass threshold than an average human being would be, which means the average human being has more room for growth (Lewis, 2020, p.12).

In the experiment, the means of measuring strides made between the athletes was determined by the amount of weight moved in a one repetition maximum lift in both the bench press and the box squat. The group was split into two random groups, the first group given a weekly anabolic steroid shot, and the second group receiving an extensive workout plan. The experiment was designed to last over the duration of ten weeks. The group who received the steroid shot was to inject the shot every Sunday for the duration of the experiment, while the second group was to just follow the plan they were given exactly as directed (Lewis, 2020, p.12).

In the women's experiment, the two groups were tested first in the bench press and then given a day of rest before attempting the box squat. This is how the baseline would be established. This would also be the same method used to measure the strides made at the end of the experiment. Group one, which is the steroid group, had an average bench press of 88.7% of their body weight. Meanwhile, group two was capable of bench pressing 91.2% of their body weight, so group two started out with a three percent edge over group one (Lewis, 2020, p.13). However, group two was able to gain an edge over group one in the box squat, as group two was

able to squat an average of 137.4% of their body weight. Group one was only capable of squatting 133.1% of their body weight (Lewis, 2020, p.13).

At the end of the ten weeks, the two groups were brought in to be tested again. Group one was tested first on the bench press and demonstrated an average of benching 99.1% of their total body weight, adding up to a 10.4% increase. Group two also increased their bench press, but only by 2.6%, for a total of 93.8% of their total body weight. Concerning the strides made in their squats, group one was able to increase their squat average by 17.3%, adding up to a total of 150.4% of their total body weight. Group two again also increased their maximum squat weight, but only by 5.7%, which adds up to 143.1% (Lewis, 2020, p.13).

The men showed a similar trend in their experiment, where the two groups had a similar baseline, but the anabolic steroid group ultimately ran away with the competition, as expected, after the ten-week program was finished. At the baseline testing, groups one (the steroid group), was able to bench press 160.2% of their body weight, and squat exactly 200% of their total body weight. Group two on the other hand, was capable of bench pressing 162.4% of their body weight, while also being able to squat 204.4% of their body weight (Lewis, 2020, p.14).

At the end of the ten-week program, group one proved to make much bigger strides in their strength than group two did, despite not working out during that period. Group one was able to increase their bench press by 16.7%, adding up to 176.9% of their body weight. Their squat increased by 19.6%, which added up to 219.6% of their body weight. Group two on the other hand was only able to increase their bench press by 5.3%, and their squat by 7.8%. This added up to be a total of 167.7% of their body weight on bench, and 212.2% on the box squat (Lewis, 2020, p.14).

To summarize the results of the experiment, the women who took anabolic steroids without working out were able to increase both lifts by 27.7% relative to their body weight. The men who took the steroids were able to increase their lifts in total by 36.3%. The non-steroid group for the women added up to a total of 8.3% increase in both lifts, while the men experienced a 13.1% increase. The men did make more progress than the women did, but the progress made by the two comparable groups were consistent throughout, as the first groups only had about a nine percent difference in their progress, and the second groups only had a five percent difference. Biologically speaking, steroids do not seem to work more efficiently on men, even though the anabolic steroid is a derivative of the male sex hormone.

The experiment proves the theory that anabolic steroids are a completely unfair advantage in competition empirically. Imagine never having to lift weights to become stronger. The workout program that the athletes were given was a high-volume plan, that required the athletes to be in the gym lifting weights for approximately ten hours a week. The anabolic steroids were not only able to give the first groups bigger strides, it also gave them those ten weekly hours back to do something else.

In total, the anabolic steroids gave the first groups 100 hours of free time. Ten weeks of anabolic steroid shots have the ability to outperform 100 hours in the gym. The integrity of athletic competition would be lost if these shots were made legal, because essentially anybody would be able to push their body to the extreme limits in the gym while using anabolic steroids. However, casual weightlifters who do not compete do not typically turn to anabolic steroids for a reason. Out of all the performance enhancing drugs discussed in this paper, anabolic steroids have been proven to be the most dangerous when it comes to side effects, both long and short-term.

With how effective anabolic steroids have proven to be in the weight room, it would make perfect sense for them not to be prohibited and allow all weight lifters to reach their maximum potential. That would be the case if they were not such a dangerous drug that can lead to many medical complications. With the overload on testosterone, which should only be produced autonomously, there comes side effects that hinder the human body's cardiovascular system, hormonal system, the immune system, the musculoskeletal system, the epidermis, the liver, and the psychiatric well being of a person (Beardsley, 2020, p.5).

Concerning the cardiovascular system, a person who is abusing anabolic steroids is likely to face a battle with high blood pressure, which often leads to blood clots, heart attacks, strokes, and permanent artery damage. All of these complications typically lead to a premature death. This is also the case with how anabolic steroids affect the liver. The liver becomes susceptible to peliosis hepatis, which is a condition where the liver develops cystic blood-filled cavities that are randomly distributed throughout the organ. This disease can be asymptomatic, but anabolic steroids can push the disease to its extremities, which means the cysts could rupture, resulting in hemorrhage, or even death (Beardsley, 2020, p.4).

The hormonal system is tampered with differently among men and women. Men are more likely to experience a decrease in sperm production, in addition to shrinkage of the testicles. Men are also likely to experience enlarged breasts, and male-pattern baldness. While none of those have proven to be fatal, testicular cancer has. It is somewhat rare for a man to suffer from testicular cancer when taking anabolic steroids, but about 25% of the men who do will not survive the prolonged battle (Beardsley, 2020, p.5). Women do not suffer from any potentially fatal diseases that attack the hormonal system like men, but they can face somewhat similar complications. Instead of testicle shrinkage, women may see a reduction in breast size. They may

also be likely to experience a deepening of their voice, as well excessive body hair growth. Women are also likely to suffer from male-pattern baldness and experience coarseness of the skin. Essentially, women will start to become more masculine if they abuse anabolic steroids (Beardsley, 2020, p.5).

The immune system faces a major battle, as anabolic steroids deteriorate its ability to fight battles against some of the nastiest sexually transmitted diseases. Some of these diseases include blood-borne viruses like hepatitis B and C, but the major risk comes with an increased risk of contracting HIV or AIDS. A study held by the National Center for Biotechnological Information displayed that about 1.5% of people who regularly inject themselves with anabolic steroids suffer from HIV or AIDS (Lewis, 2020, p.21). That may seem like a small percentage, but when you compare that to the worldwide rate of 0.5%, it is quite inflated (Global Statistics, 2021, p.1). With a compromised immune system, there is a high chance that somebody who abuses anabolic steroids will face death when they contract the COVID 19 virus since the virus has proven to be fatal to those with weaker immune system, and underlying conditions.

With young athletes, especially in high school, looking for a fast and easy way to increase their physical strength, there should be more of a push to raise awareness about how anabolic steroids can stunt growth within adolescents. This happens because they excess testosterone forces the musculoskeletal system to mature at a rapid rate, thus solidifying the bone and muscle structure as it is in terms of length and girth. The muscles will still be able to grow bigger and stronger obviously, but they will not grow any longer. The bones in the human body basically become stagnant as where they were when the beginning of the steroid abuse began. With muscles not being able to elongate, this also puts athletes at a higher risk for suffering from an injury such as a torn ligament or muscle (Beardsley, 2020, p.7).

With anabolic steroids just being an injectable shot of male hormone, some immediate side effects are like those when a young man starts to go through puberty. Aside from the abscess that can be found at the site of injection, a person who decides to use steroids will also see their skin become very oily constantly and suffer from severe acne and possibly cysts (Beardsley, 2020, p.5). Many people often joke about how puberty is the worst time of their lives, mostly because of all the embarrassing things just like these side effects that anabolic steroids are promised to come with, so it would not make much sense to recreate the worst time of your life, jokes or not. This is just a small price to pay when compared to the other side effects that can be death inducing. Most of them are due to some kind of physical failure, but anabolic steroids can disrupt mental processes too.

The psychiatric well being of somebody who takes anabolic steroids can suffer tremendously, especially if it is somebody who already suffered from a mental illness. There is a side effect to anabolic steroids that most people refer to as 'roid rage.' The reason for this name is because anabolic steroids tend to make people become far more aggressive than usual. People who misuse anabolic steroids have reported that have been in multiple street fights, verbal altercations with strangers, and have been an offender of domestic violence towards their significant other (NIDA, 2021, p.2). On top of roid rage, anabolic steroid users are also more inclined to report problems with anxiety and stress than somebody who does not use steroids at all. Some mood disorders that cause these problems include those such as mania, hypomania, and major depression (Beardsley, 2020, p.7). Recently, there has been an effort to raise awareness about mental health by the general public, especially in the National Football League with so many athletes coming out about their battles with depression and anxiety. Dak Prescott of the Dallas Cowboys is the main advocate for bringing awareness to mental health, and has been

on record saying, "I think it's huge to talk. I think it's huge to get help. And it saves lives", when asked about the importance of opening up about mental health struggles (2020, p.1). The research shows that suicide from mental health struggles can be just as deadly as any other disease or virus known to man. The psychiatric effects from anabolic steroids are not ones that should be overlooked just because they do not relate to the physical well-being of a person.

Overall, anabolic steroids should never be touched for performance enhancement. Taking anabolic steroids for performance enhancement, or in many cases for appearance, is irresponsible and quite frankly, idiotic. Aside from the muscle mass one person will gain, that is hardly a true benefit when taking the possible muscle, skeletal, and mental deterioration into consideration. Taking anabolic steroids just for appearance is not even a safe bet because most often people's muscles become asymmetrical and abstract. Even though anabolic steroids may be the most effective performance enhancing drug known to man, it is also the most dangerous.

### **Conclusion**

Since humans have been playing sports, it has all been about competition, and it is human nature to want to out perform your peers, whether it is just a friendly match or for a championship ring. Humans will do anything to gain the upper hand on their opponents, even if it means breaking the rules and the destroying the integrity of the game. Whether it is the 2017 Houston Astros, who were stealing signs from the opposing team which helped them win a World Series, or the 2014-2015 New England Patriots team who allegedly deflated footballs to a pressure that did not meet NFL regulations before a rainy AFC Championship game against the Indianapolis Colts, making them easier to throw and catch in the weather conditions. All the performance enhancing drugs and supplements that have been listed were created and have been used to do just that.

Of course, some of those supplements are perfectly legal and there is nothing wrong with wanting to use them to try and push yourself over the plateau in progress you may be facing. However, there are many supplements and drugs out there that have been normalized even though they contain ingredients that have been banned by most athletic administrations and associations.

Thousands of student athletes within the NCAA fail a drug test every year, and most cases are due to students consuming some kind of substance or supplement that they were unaware of (NCAA, 2021, p.1). This could be from something as simple as drinking too much coffee or taking a pre-workout supplement that a friend recommended because he or she has seen significant progress in the weight room ever since they started taking it and not asking any questions about it before consuming it.

The strides made by athletes taking supplemental support compared to those athletes who do not use any kind of supplement at all really depends on the supplement itself. If both athletes are on the same workout plan, the athlete who is taking supplements should see faster progress than his or her counterpart. That progress can mean so many different things as well, which is completely reliant on the supplement being used.

Athletes who take creatine will probably feel more energized and have a longer tolerance for resistant training or activity than those who do not use creatine. This could give the athlete who is using creatine an advantage on the field when talking about performing at a high level for much longer than usual. In the weight room, creatine is helpful for accelerating the training process by allowing athletes to complete higher volume workouts than if they were not on creatine. The main advantage to taking creatine is simply endurance related to the muscle-body connection.

Stimulants, on the other hand give an advantage to the mind-body connection. Not only do most legal stimulants produce adrenaline and give the person a sensation of heightened awareness and awareness, but they also block the production of melatonin temporarily. Stimulants do supply energy to the body, but the origin is all in the brain, whereas in creatine it begins in the muscles.

Then there are supplements that assist with recovery like amino acids and protein. While amino acids are the building blocks for protein, it is important to be able to differentiate between the two. Think of amino acids as broken down, specific variations on protein. Some amino acids might help with rebuilding muscle fibers right after a workout, and others may help with strengthening the skeletal system. Those are just two examples, as there are many different amino acids with a plethora of different functions. Taking amino acid supplement is beneficial, but only when extensive research is done on what amino acids are right for the person's specific wants and needs.

Protein supplementation is much more straight forward. Protein in general is the macronutrient that helps with muscle synthesis. With protein being a macronutrient, the supplement can add onto daily caloric intake. Protein supplementation should never serve as a meal replacement though, as meals should always consist of carbohydrates and fats as well. Protein supplementation is effective for athletes who are looking to put on muscle weight, thus making them stronger in the weight room relative to the total amount of weight lifted.

Nitrate supplementation is rare, but it is out there for athletes to use. Since nitric oxide is a natural substance in the body that supplies energy, nitrate supplements just serve as a different form of energy supplier, but nitrate does it by widening the blood vessels in the body. Essentially,

the natural process of oxygen transport is enhanced when a person takes a nitrate supplement. However, there is little evidence that supports the effectiveness of nitrate supplementation.

On the contrary, anabolic steroids have all the evidence in the world that support how effective they are in terms of performance enhancement. So much research has been done on anabolic steroids that they have been banned by almost every professional athletic organization in the world. While they do allow athletes to reach new peaks in their abilities, the complications that come with them are far too much to risk. There is no performance enhancing drug on the planet that has been proven to be more deadly than anabolic steroids.

Young athletes are impressionable, especially when it comes to wanting to be like their favorite professional athlete. Professional athletes have much more influence than they may know, and it can be misleading when they advertise their products that they use. Often time these professionals just advertise a product without explaining the specific reason as to why they take it just because there is quick cash in that business. Younger athletes need to be conscious of that and realize that every human is built differently. Every athlete has specific needs that cater to them and only them. Before purchasing a supplement, it is imperative that you do extensive research on that product. Make sure to educate yourself on what the product is composed of, what it is advertised to do, what you are trying to accomplish by taking the product, and how that all relates together. All in all, supplementation can be useful to helping athletes make faster progress, but what really matter is the effort being put into the actual training process.

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