NASM
NATIONAL ACADEMY OF SPORTS MEDICINE

THE NASM GUIDE TO

CREATINE FOR WELLNESS AND LONGEVITY

Contents

Welcome!

Welcome to the National Academy of Sports Medicine's guide to Creatine for Wellness and Longevity. We hope you find the provided framework and strategies empower you to pursue your wellness goals with clarity and direction. Knowing where to start when working on your well-being can be challenging, especially if you feel overwhelmed by all the available options and resources. Creatine is a much-studied and versatile supplement with emerging positive health effects beyond its traditional use for muscular development, strength, and performance. This guide will provide information on creatine's benefits beyond these uses that can help you decide if it is right for your supplement routine.

About NASM

The National Academy of Sports Medicine is the leader in educating and credentialing fitness, wellness, and performance professionals across the globe. NASM provides valid, up-to-date learning content on topics that improve the health and well-being of those they serve. We pride ourselves in creating practical content you can apply right away. Learn more at www.nasm.org, your favorite social media platform, or wherever you listen to podcasts.

Getting the Most from This Guide

This guide will walk you through information explaining what creatine is, how it works, how to take it, and its possible benefits. We'll make sense of the large volume of information available on creatine, so you won't have to. Then, you'll be equipped with actionable steps to apply whenever you like.

Come back and use the information as a reference at any time. Be sure to return to the FAQs in the Resources section whenever you need a quick refresher on the content. Do not feel obligated to put everything into action right away. Most importantly, be patient with yourself and your journey. A little self-compassion goes a long way.

Introduction

Creatine is a well-established dietary supplement to enhance exercise performance. A growing body of research is making a solid case for creatine to be one of the best supplements for overall health and wellness across the lifespan. Despite the strong scientific rationale and well-documented benefits, numerous misconceptions and myths persist. So, let's start with some basics before exploring the latest scientific discoveries.

Creatine History

Creatine was first isolated and extracted from meat nearly 200 years ago in 1832 by a French philosopher and scientist, Michel Eugene Chevreul, who is considered the founder of modern organic chemistry. The first creatine supplementation study was conducted in 1926 (Chanutin & Guy, 1926). The author and his assistant ingested 10 grams of creatine per day and discovered that "during the first few days of creatine feeding, its retention by the body [was] striking." This incredible discovery provided the first evidence that the body could absorb and store ingested creatine. However, the benefits of retaining creatine were not known until nearly 70 years later, in the 1990s, when Drs. Roger Harris and Eric Hultman revealed that creatine was being retained primarily (~95%) within the muscles and that creatine can be converted to phosphocreatine and used to make energy. Dr. Harris discovered that following a short-term supplementation regimen of 20 grams daily for six days dramatically increased the amount of creatine and **phosphocreatine** in the muscle. This was the first evidence that making a simple dietary change could increase the capacity of this energy system. These pioneering researchers and findings have greatly influenced creatine research and have played a vital role in what we currently know about creatine supplementation.

CHECK IT OUT

Creatine's name is derived from the Greek word for flesh.

What is Creatine?

Creatine is comprised of three amino acids: arginine, glycine, and methionine. Understanding these amino acids' chemical and molecular structure is not critical to reaping their benefits. The important part is that creatine is not a steroid, despite what is often claimed on social media. If you ingest protein, you are ingesting amino acids. There is a common fear that creatine will destroy your liver and kidneys. The reality is your body is currently making creatine. Every person on this planet already has creatine within their bodies, and this molecule plays a critical role in the body to support proper functioning and enhance overall health.

Why do we need a supplement if the body can make it? The short answer is that your body can only make creatine at a limited rate (about 1 gram per day), and if you want your cells to function at their best, then creatine-containing foods or supplements will help. Red meat, seafood (e.g., herring and salmon), and chicken are all great food sources of dietary creatine. However, to achieve 5 grams of creatine from these food sources, you would have to eat a considerable amount. For example, you would have to consume 1.1 pounds of herring or 2.5 pounds of salmon daily. This is not sustainable, and is why nearly everyone can benefit from creatine supplements.

Further, suppose you are a vegan or vegetarian. In that case, you will be missing out on these creatine-containing foods, and it is well-established that vegans and vegetarians have lower amounts of creatine within their muscles. The good news is that vegans or vegetarians are physiologically more responsive to taking a creatine supplement (Kaviani et al., 2020). If one has lower muscle creatine levels (e.g., vegetarians), they will see more significant increases following supplementation and weight training on gains in muscle mass and performance (Burke et al., 2003). One question that often emerges is whether creatine supplements are derived from animal products, and the answer is no. Creatine supplements are synthesized from non-animal products, so vegans and vegetarians can take them. However, even if you are an omnivore or eat meat, your cells will still not be saturated with creatine from your diet alone. Following supplementation, you will get about a 20% increase in total creatine (free creatine and phosphocreatine) within your muscles (Kreider et al., 2017).

How Does Creatine Work?

This section is technical but stick with it. A molecule called adenosine triphosphate (abbreviated ATP) is the energy currency within a cell. The name refers to its structure: an adenosine molecule with three phosphates attached, hence the *tri*phosphate. Anytime a cell requires energy, it will break down, or "spend," an ATP molecule. During spending, one of the three phosphate groups drops off. And a spent ATP molecule is now called adenosine *di*phosphate (ADP). Think of creatine as a wallet of extra phosphate groups. When this creatine wallet has phosphates within it, it is considered phosphocreatine. It loans a phosphate group to an ADP molecule, and boom, you have ATP again, ready to spend.

This phosphocreatine system is one way our bodies maintain our ability to perform movement. Besides the phosphocreatine system, bodies have other fuels and energy systems in the muscle that can remake ATP molecules. Each of these systems has differences in ATP production speed and capacity. Ultimately, the body must make ATP molecules at the same rate at which it uses them. Cells will not work optimally if the body cannot match ATP needs with production. This can create stress on the cells and lead to several problems, such as fatigue in the short term or accelerated aging over the long term.

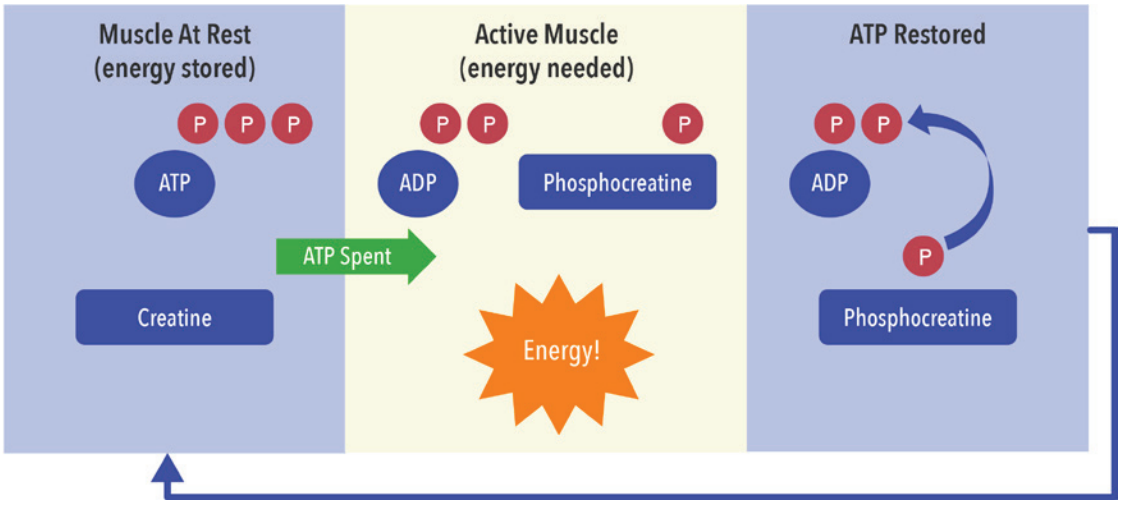


Figure 1. ATP Phosphocreatine Shuttle

So, why is having more creatine and phosphocreatine in muscles advantageous, and how does creatine work within a cell? The answer is that compared to other energy systems, phosphocreatine can replace ATP very quickly, and it does this without the requirement of oxygen. Therefore, the phosphocreatine energy system is critical when cells are under a lot of stress and quickly use energy (and therefore ATP). It is perfect for explosive activities like intense exercise or strength training. However, it is also important for activities where you shift from being relatively still to moving, like standing up from a chair. This energy system could also be critical when the heart or brain are deprived of oxygen, such as during a stroke or heart attack. Having more creatine or phosphocreatine gives cells a greater capacity to make energy quickly (Forbes et al., 2020), respond to environmental changes, and mitigate the amount of stress on your cells. There is evidence that creatine acts as an antioxidant and reduces inflammation, again showing that creatine can reduce cellular stress.

How to Take Creatine

There are several scientifically proven strategies to take creatine. However, the dose will depend on your goals and the tissue you are trying to improve (e.g., bone, brain, muscle, heart).

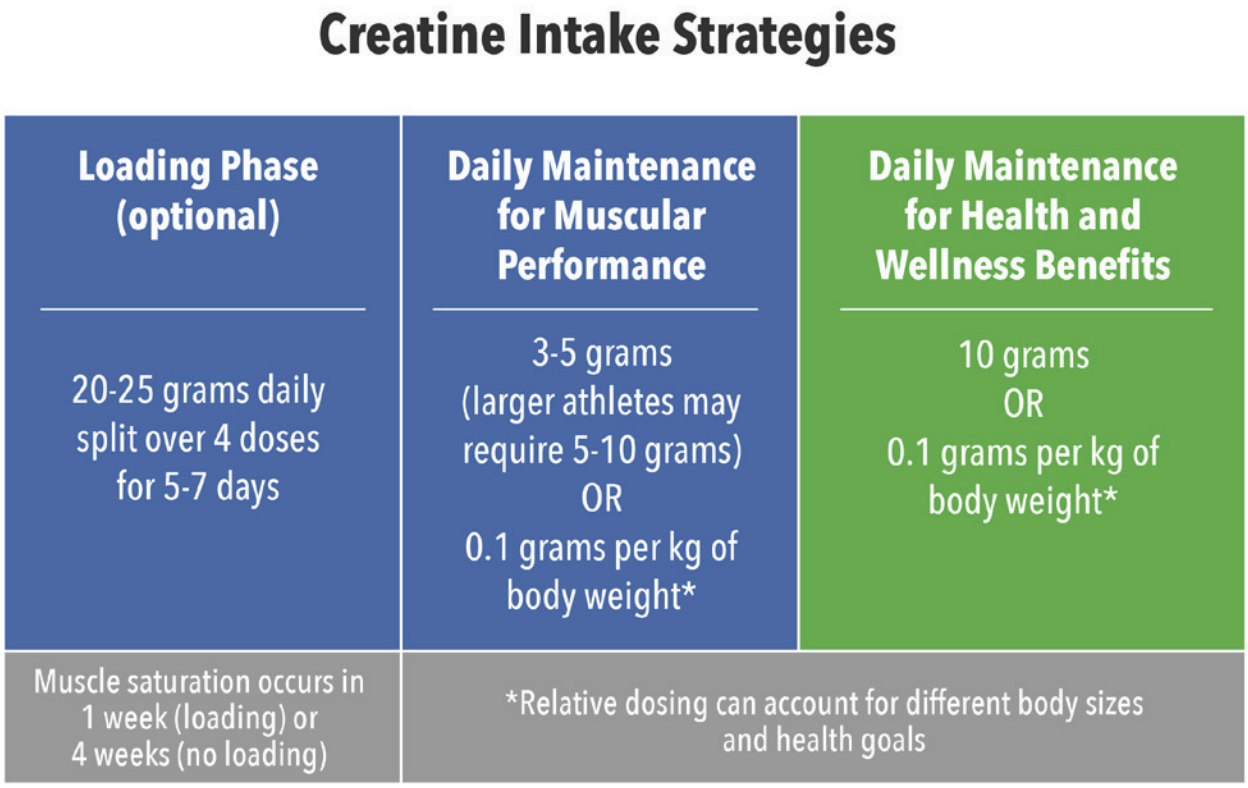


Figure 2. Creatine Intake Strategies

- **Strategy 1: Loading Protocol:** The most common protocol includes a "loading phase," which is typically taking 20 grams per day split into four different servings (5 grams each in the morning, at lunch, at dinner, and before bedtime for a total of 20 grams) and you will do this daily for one week. Following this loading phase, you will only require 3 to 5 grams daily to maintain those elevated creatine levels. This loading strategy is very effective; however, only some of the ingested creatine is taken up by the muscles. Some people (albeit very rare) may experience some stomach discomfort when taking 20 grams daily.
- **Strategy 2: Low Dose Protocol:** Another strategy that may be easier on your stomach and is just as effective from a muscle perspective is skipping the loading phase entirely and taking 3 to 5 grams of creatine daily. This strategy will saturate your muscles with creatine to the same level; it just takes a bit longer (28 days compared to 1 week).

- **Strategy 3: Relative Dosing Protocol:** The final strategy is taking a relative dose of creatine based on your body weight, or 0.1 grams per kilogram of body weight per day. For example, if you weigh 70 kilograms, you take 0.1 x 70 or 7 grams of creatine daily. This strategy has been used extensively in scientific papers and is excellent for people who are either smaller or larger than average or if you have specific health goals to enhance bone (we will discuss that below).

All three strategies are equally effective at enhancing muscle while strength training. However, the scientific literature supports the idea that a higher dose of creatine is optimal for bone and brain health (Forbes et al., 2021).

HELPFUL HINT

To calculate your weight in kilograms, divide your weight in pounds by 2.2.

Optimizing Creatine Ingestion

Beyond dosing protocols, there are ways to maximize creatine absorption and retention. First, creatine should be ingested with carbohydrate and protein sources. Both nutrients will stimulate insulin and help your muscles take up creatine faster.

Additionally, take creatine close to exercise since exercise stimulates creatine transporters to take up more. This was shown in a unique study. Participants exercised one leg and kept the other still using a specialized stationary bike. After exercise, study participants ingested creatine. Researchers found that the exercised leg had greater creatine uptake and retention than the unexercised one (Robinson et al., 1999).

Another study reported more significant gains in strength and muscle mass and a more considerable decrease in percentage body fat in participant groups that ingested creatine closer to their training time as opposed to 5+ hours in other groups (Forbes et al., 2021). There is no difference between taking creatine before or after training, so from a practical perspective, taking creatine at a time that works best for you to take it consistently (such as with a protein shake) will suffice (Forbes et al., 2021). On rest days or if you do not engage in structured exercise, you can ingest creatine at any time throughout the day.

Other commonly asked questions include what happens when you stop taking creatine or does it matter when you miss a day of supplementation. Once your muscles are saturated, it takes 4 to 6 weeks to return to baseline; therefore, if you miss a day, it will not have any meaningful or negative effect. Creatine, only taken on days you work out, is an effective strategy to enhance upper and lower body muscle strength and gains in muscle mass compared to placebo (Forbes et al., 2021). Collectively, just taking creatine over a period of time will lead to enhanced results. See the FAQ in the resources section for a summary of common questions and answers about creatine ingestion and absorption.

Creatine Safety

Despite strong scientific support for the safety of creatine, there remain several myths and misconceptions, including that creatine is harmful to your kidneys, causes hair loss, or is not for people assigned female at birth, all of which are entirely untrue (Antonio et al., 2021). Remember that your body naturally produces creatine and that creatine is found in food sources. However, it is essential to note that an excessive amount of anything could be harmful. Even water can lead to water intoxication! So, please stick to the recommended doses outlined previously or as indicated on your supplement bottle. For example, in an extreme case, a 27-year-old bodybuilder reported taking 210 grams per day of creatine (22 times the recommended dose) in addition to anabolic steroids. This resulted in kidney issues, including hardening of the walls of the arteries in the kidney and scarring of kidney tissue (Hartung et al., 2001).

In contrast, some individuals exaggerate the benefits of creatine. Creatine is not a magic pill or powder; it can enhance health and performance, but it needs to be put in perspective. As such, despite the evidence that creatine is an effective dietary supplement in a variety of situations, creatine should not be used in place of medical treatments, nor will creatine turn someone into a superhero with optimal health! Further, some of the benefits of creatine will only appear when a person is already exercising regularly, ingesting sufficient calories, and meeting their protein requirements. Healthy lifestyle behaviors like sleep and eating real food are critical for optimal health, wellness, and longevity. Creatine is a supplement to a healthy lifestyle, not a replacement for it. The science is clear: creatine can help in various situations, and there is emerging data, so let's tackle those next.

CRITICAL

Creatine is not a magic pill and should not be used in place of medical treatments.

GETTING TECHNICAL

In typical situations, if a by-product of creatine metabolism known as creatinine goes up, this could indicate kidney dysfunction. However, having a large amount of muscle or taking a creatine supplement may increase your creatinine levels. Importantly, this does not mean your kidneys are being damaged; this is because of normal creatine metabolism. Creatine is non-enzymatically degraded to creatinine. Other blood markers, such as Cystatin-C, should be used to assess kidney function when taking creatine. The evidence is strong that taking creatine in the recommended doses is very safe if you are healthy.

Creatine's Benefits

Creatine research is multiplying, and despite most of your creatine being stored within your muscles, creatine is also found in other tissues (e.g., bone, brain) and, therefore has a bearing on health beyond just muscle. Originally, creatine supplements were thought of as just for young exercising individuals, mainly bodybuilders wishing to enhance muscle mass and strength. Still, there is growing evidence that creatine can help older adults preserve muscle health and function as they age (Delpino et al., 2022).

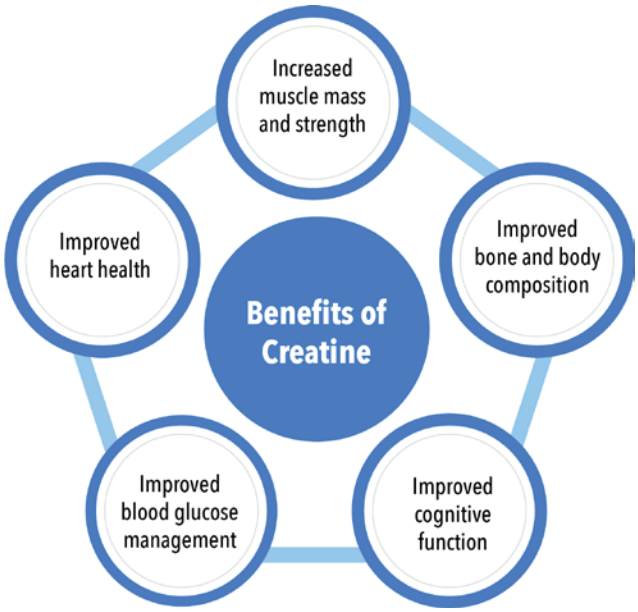


Figure 3. Benefits of Creatine

Muscle Mass and Strength

Creatine's benefits to muscle and strength move well beyond bodybuilding and performance. Skeletal muscle is one of the most critical tissues in the body. Muscle mass and the ability to activate muscles is essential for health and longevity. Muscles use glucose as a fuel to make ATP and help to control blood sugar after a meal, thus lowering the risk of diabetes. This is why an often-recommended health tip is to walk after eating a meal, activating the muscles and reducing blood glucose (Myette-Côté et al., 2018).

In addition, having stronger muscles is one of the critical determinants of independence later in life. We also know that the average person starts to lose muscle after age 40, and if they lose too much muscle, it is known as **sarcopenia**. Sarcopenia can have devasting effects on health and one's ability to function. The good news is that creatine, combined with strength training, will likely enhance muscle mass and strength. Since a common myth surrounding creatine is that supplementing alone will cause muscle gain, it is important to note that it must be combined with strength training for muscles to benefit. Exercise is crucial for health and longevity, and creatine can help, but only when exercising regularly. The current exercise recommendations are to do strength training twice a week and moderate cardiorespiratory exercise that accumulates to 150 minutes a week (or about 22 minutes a day). In a recent review, it's clear that creatine must be combined with exercise to enhance muscle mass and strength (R. Burke et al., 2023; Delpino et al., 2022). Specifically, creatine is an effective supplement to improve muscle mass and strength (both upper and lower body) in older adults. In addition, creatine combined with strength training can improve muscle function. One test to evaluate muscle function is a sit-to-stand task, which involves repeatedly sitting down and standing up. Science is clear that creatine can help improve this task. Poor sit-to-stand scores have been associated with an increased risk of

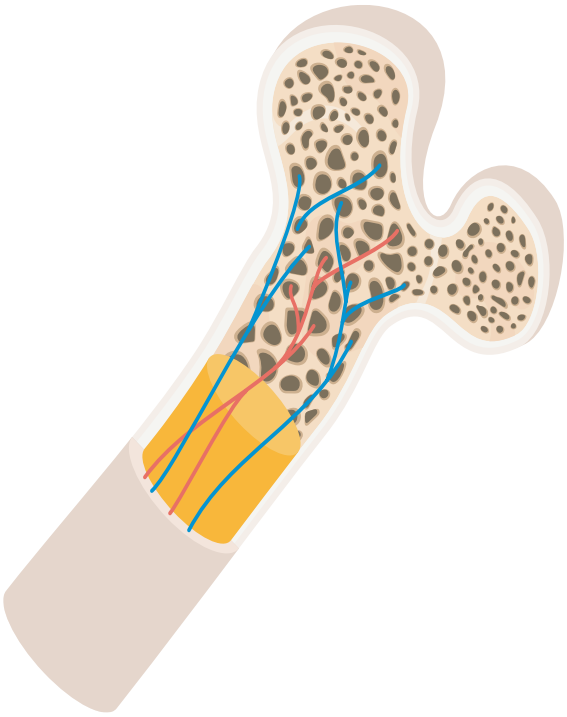
falls (Lusardi et al., 2017). Therefore, creatine may be combined with other strategies to lower the risk of falls. Presently, the evidence is clear: creatine is one of the most effective dietary supplements to enhance muscle mass and strength and works across the lifespan, and these gains can have a profound bearing on health and wellness.

Bone and Body Composition

When discussing improving bone health, we often consider bone mineral density. Creatine, however, does not affect bone mineral *density* but rather the bones' *strength*. In theory, creatine affects bone directly since bone cells rely on the phosphocreatine energy system, and creatine increases **osteoblast** activity in bone cell culture models. If we think of bone as a brick wall, osteoblasts add bricks to the wall, and **osteoclasts** are cells that remove bricks. If one can increase osteoblast activity, they will build a bigger and stronger wall (i.e., bones). Creatine may also indirectly enhance bone. Creatine is one of the most effective dietary supplements to improve muscle mass and strength. Since muscles pull on tendons and tendons are connected to bones, stronger muscles will transmit greater tension to the bone, stimulating bone formation over time. This is how strength training improves bone density.

While creatine may help with bone's cellular activity and bone formation over time, a review of research studies suggests that creatine has no significant effect on bone mineral density when combined with strength training (Forbes et al., 2017). However, it was found that bone geometry (i.e., bone shape) was enhanced by creatine supplementation. Bone geometry may be a better predictor of bone strength than density.

If we continue with our brick wall comparison, creatine may help arrange the bricks to create a stronger wall. Notably, these benefits were not found with taking creatine alone without exercise (Sales et al., 2020). More research is also needed to determine if creatine supplementation may reduce the risk of fractures in older adults.



What does this all mean based on current science? To improve bone strength, the following conditions should be met:

- Because bone tissue turnover is slow, creatine and strength training should be combined for at least 9 months.
- The daily dose should be approximately 10 grams per day or the relative dosing strategy of 0.1 grams per kilogram of body weight (Forbes, Ostojic, et al., 2021).

Cognitive Function

There is emerging evidence that creatine supplementation can enhance brain creatine levels and brain function (Candow et al., 2023; Forbes et al., 2022). The brain differs from muscle because it can synthesize or make its own creatine. In addition, it is challenging for creatine to get into the brain and pass the **blood-brain barrier**. Creatine, in contrast, is readily taken up by muscle. In an animal study, four weeks of creatine supplementation improved memory, learning, and mitochondrial function (Snow et al., 2018). In humans, there is also a growing body of evidence that creatine can influence brain health, particularly in older adults (Prokopidis et al., 2023). The most comprehensive review on the topic was recently published, and it noted that higher doses of creatine for extended periods might be required to achieve brain benefits (Candow et al., 2023).

The researchers also pointed out that the effects of creatine may be more robust when the brain is stressed. For example, research has shown that creatine can help your brain function better compared to placebo following sleep deprivation, mental fatigue, or during hypoxia (a low amount of oxygen) and may help recovery following a traumatic brain injury or concussion. Although limited, these findings have the potential to play a critical therapeutic role in certain situations, including those with dementia, military personnel, first responders (Mattos et al., 2023), and those suffering from repeated head impacts, such as American Football players (Alosco et al., 2020). Creatine supplementation may help because these populations exhibit altered brain metabolism and lower brain creatine levels. Future research is needed to validate and confirm creatine's therapeutic benefit.

In addition to cognitive function benefits, creatine appears to influence mood, including anxiety and depression (Candow et al., 2023). In a study of over 22,000 US adults, participants were divided into categories based on how much creatine they were getting in their diet. Researchers noted a significant difference in depression prevalence between the highest and lowest groupings of dietary creatine intake. Put simply, the more creatine you have in your diet, the lower the risk of depression. This relationship is not strong enough in the current scientific literature to suggest creatine as part of a mental health treatment plan, but it does show promise. Future **randomized controlled trials** are required to determine whether dietary creatine intake or creatine supplementation can reduce the risk of depression.

Blood Glucose Management

The effects of diabetes are well-established. A lesser-known effect of creatine is its ability to increase the number of glucose transporters (GLUT-4) in a muscle cell. Currently, only a couple of studies have investigated the effects of

creatine supplementation in individuals with type 2 diabetes. Interestingly, five days of creatine supplementation of 6 grams per day had a similar impact on lowering blood glucose (sugar) compared to metformin (a commonly prescribed blood sugar lowering drug) (Rocic et al., 2009). In another study that included 25 participants with diabetes, creatine supplementation of 5 grams per day in conjunction with an exercise program for 12 weeks, HbA1c was reduced in the creatine group compared to placebo (Gualano et al., 2011). HbA1c is a blood marker representing an average blood glucose level over the past 2 to 3 months. Overall, there is promising evidence that creatine enhances glucose control. However, caution is warranted due to the small sample sizes and limited studies. As mentioned before, creatine is not a supplement that solves health problems but a beneficial additive to an already healthy lifestyle.

Heart Health

Another emerging area of research is investigating creatine's role in heart health. The heart contains a high concentration of creatine. This is due to the importance of creatine acting as an energy buffer during stress. For example, during ischemia (reduction of blood flow and oxygen), it is possible to support heart tissue with the creatine energy system. However, since there are fewer creatine transporters in the heart, increasing creatine content (like in the brain) is challenging. Based on the available literature in both human and animal models, creatine content can be increased, but a higher dose of creatine over a more extended period is required. In healthy individuals, creatine supplementation has no detrimental effect on cardiac function. In addition, creatine supplementation has been proposed to enhance heart health in specific situations such as heart failure and heart ischemia; however, limited data exists (Balestrino, 2021). There is clear evidence that creatine can improve heart failure patients' muscle health (strength and endurance). Therefore, creatine can ameliorate muscle weakness typically associated with this condition (Balestrino, 2021).

Summary

Overall, there are several emerging and promising benefits of creatine supplementation to enhance health and wellness, particularly in an aging population. Creatine combined with strength training enhances muscle health (muscle mass, strength, and function) and bone health in older adults. It is important to remember that creatine supplementation must be combined with strength training to reap these benefits. Creatine supplementation also appears to enhance cognitive function or brain health, blood glucose management, and heart health. Again, the recommendations would be to combine creatine with exercise, albeit there is some evidence that creatine may be of some benefit when provided alone, such as improving memory in older adults (Candow et al., 2023; Prokopidis et al., 2023). Creatine is also very safe and effective (Rawson, 2018). Notably, a higher dose of creatine of 10 grams per day may be required to achieve several health benefits (bone, brain, and heart), whereas 5 grams per day is adequate to enhance muscle health. Therefore, the amount you ingest may vary based on your individual goals. Lastly, the scientific evidence is clear that creatine monohydrate is the safest and most effective form of creatine (Forbes et al., 2021; Kreider et al., 2017).

Resources

Below is a convenient set of creatine FAQ that are helpful for reference or quick reminders.

TOP 10 COMMON CREATINE QUERIES

1. Which form of creatine is the best?

Creatine monohydrate. While many supplement companies will try to lure you with fancy formulations and innovations, nothing beats creatine monohydrate regarding safety and effectiveness.

2. How much should I take?

For the positive health effects mentioned here, take 10 grams daily or a daily relative dose of 0.1 grams/kg of body weight.

3. If I take creatine for wellness and longevity benefits, do I still need to do a loading phase? And do I ever need to take a break from supplementation?

A loading phase is optional and unnecessary to reap wellness and longevity benefits. There is no need to take a break unless you experience gastrointestinal discomfort.

4. Should I take creatine with food?

Food is not required, but creatine ingested with carbohydrate and/or protein sources will stimulate insulin and help your muscles take up creatine faster.

5. Do I need to exercise when I take creatine, even if I'm taking it for reasons other than bodybuilding, strength, and athletic performance?

Yes. Creatine should be combined with exercise and strength training to optimize its wellness and longevity benefits.

6. Should I take creatine before or after exercise?

It's up to you. So long as you take it close to an exercise session, there is no difference between taking creatine before or after a workout.

7. Does it matter when I take creatine on non-exercise days?

No. On rest days (or if you do not engage in structured exercise), you can ingest creatine anytime throughout the day.

8. I've noticed my creatine doesn't always dissolve completely in cold water; what helps?

Creatine does not have to be 100% dissolved to be absorbed. Creatine does, however, mix more easily in warm water or hot tea. You can also try mixing your creatine in juice because the altered pH in juice makes it easier for creatine to dissolve, and the carbohydrates in juice will enhance creatine uptake- bonus!

9. What happens when I miss a day?

If you miss a day, it will not have any meaningful or negative effect. Overall, simply taking creatine over a period of time will provide benefits.

10. What happens when I stop taking creatine?

Once your muscles have reached their saturation level, it takes 4 to 6 weeks to return to baseline levels.

Key terms

Creatine	A compound derived from three amino acids, arginine, glycine, and methionine. It can be converted to phosphocreatine and broken down to energy quickly.
Phosphocreatine	A key component of a system in the body that produces energy rapidly to meet immediate demands. Supplementing with creatine boosts stores of phosphocreatine.
Sarcopenia	Sarcopenia is an age-related loss of muscle and strength that reduces one's ability to perform activities of daily living.
Osteoblasts	Cells that are important in the formation of new bone.
Osteoclasts	Cells responsible for the breakdown and absorption of bone as part of the normal tissue turnover process.
Blood-brain barrier	The system of blood vessels and specialized cells that regulate what can enter the brain's circulation from the body's general circulation.
Randomized controlled trials	Research experiments that control factors not under direct study. They are used to measure the effectiveness of an intervention or treatment.

About the Author

Dr. Scott Forbes is a faculty member at Brandon University in Manitoba, Canada. His primary professional and academic interests lie in sports science. He has focused on various nutritional and training interventions to enhance athletic performance. In addition, he has expertise in examining nutritional and exercise interventions for optimal muscle and brain health in older adults. He has worked as a personal trainer and an athlete consultant for several professional and varsity-level sports teams. He serves as Sports Nutrition advisor for the International Society of Sports Nutrition (ISSN). Dr. Forbes is also a prominent and prolific researcher in exercise and sports nutrition sciences, including creatine's benefits for sport and health, with over 120 articles published in scientific literature. His professional certifications include Certified Sports Nutritionist through ISSN (CISSN), Clinical Exercise Physiologist (CEP), and High Performance Specialist with the Canadian Society for Exercise Physiology (CSEP), and the International Olympic Committee diploma in Sports Nutrition.

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