


Factors Influencing Muscle Creatine Uptake

The strongest determinant of how much creatine will be taken up following a single dosing is whether the muscle is in a resting state (Kreider et al., 2000). Time course studies have indicated that peak muscle creatine concentrations can be achieved within 2–3 days of supplementation, with the greatest increase in muscle creatine following supplementation, whereas subjects with higher creatine levels will experience smaller increments in creatine storage. However, this does not fully explain the large intersubject variability in the response. In a meta-analysis of the factors influencing muscle creatine uptake (Table 2), it was found that the peak creatine uptake is influenced by the amount of creatine ingested, the duration of creatine supplementation, and the presence of other factors (e.g., carbohydrate or protein) during supplementation.

### TABLE 2. Factors influencing muscle creatine uptake

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect on Creatine Uptake</th>
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<tbody>
<tr>
<td>Amount of creatine ingested</td>
<td>Higher creatine uptake</td>
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<tr>
<td>Duration of creatine supplementation</td>
<td>Faster peak creatine uptake</td>
</tr>
<tr>
<td>Presence of other factors (carbohydrate or protein)</td>
<td>Increased creatine uptake</td>
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It is important to note that the rate of creatine uptake is also influenced by the quality of the ingested creatine. Poor quality creatine (e.g., micronized creatine) may result in slower and less efficient uptake compared to high-quality creatine (e.g., creatine monohydrate). This is because high-quality creatine is more hydrophilic and better absorbed by the body. The rate of creatine uptake is also influenced by the presence of other factors, such as carbohydrate or protein, which can enhance the uptake of creatine into muscle cells.

In conclusion, the amount of creatine ingested, the duration of supplementation, and the presence of other factors (e.g., carbohydrate or protein) during supplementation are the primary factors influencing muscle creatine uptake. Poor quality creatine and the presence of other factors can reduce the rate of creatine uptake, while high-quality creatine and the presence of other factors can enhance the rate of creatine uptake.

**Summary and Conclusion**

Creatine supplementation has been extensively studied over the past few decades, and the results have been mixed. While some studies have shown that creatine supplementation can improve performance in short-term high-intensity activities, such as sprinting and weightlifting, other studies have failed to find similar effects. Nevertheless, creatine is not a panacea, and it is not recommended for everyone. Creatine supplementation is generally safe, but it is important to follow the recommended dosage and duration of supplementation to avoid potential side effects. Additionally, creatine supplementation should be used as part of a comprehensive training and nutrition program, rather than as a standalone supplement. It is also important to note that creatine supplementation may not be effective for everyone, and some individuals may experience no change in performance.

**References**

Creatine supplementation and concurrent resistance training has been studied extensively in athletes focused on the effects of creatine supplementation on exercise performance. Several studies reported increased muscle creatine uptake or the ingestion of creatine with ~50 g of a carbohydrate beverage daily increased muscle total creatine by 9% more than ingestion of a carbohydrate beverage without creatine. The increase in muscle strength seen in subjects ingesting creatine during resistance training may result from creatine's ability to enhance the energy production during exercise lasting 30 seconds or less. However, this cannot fully explain the large intersubject variability in creatine following creatine supplementation (adapted from Kreider et al., 2003).

Although meta-analyses have been conducted in an attempt to compare results of many studies in an unbiased manner, there are several limitations with this statistical approach. First, meta-analyses are influenced by the purpose and the biases of the original studies. Second, the findings may not be representative of healthy adult populations. Researchers studying potential adverse events associated with creatine ingestion have focused on three areas: 1) the effects on enzymes, electrolytes, lipid profiles, hematological markers, and exercise performance on the playing field. This has not been consistently supported. Although meta-analyses have been conducted in an attempt to compare results of many studies in an unbiased manner, there are several limitations with this statistical approach. First, meta-analyses are influenced by the purpose and the biases of the original studies. Second, the findings may not be representative of healthy adult populations. Researchers studying potential adverse events associated with creatine ingestion have focused on three areas: 1) the effects on enzymes, electrolytes, lipid profiles, hematological markers, and exercise performance on the playing field. This has not been consistently supported. However, this cannot fully explain the large intersubject variability in creatine following creatine supplementation (adapted from Kreider et al., 2003).

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Anecdotally, creatine has been associated with heat illness, muscle tightness, muscle pulls/strains, non-impact injuries, and cramping has been theoretically associated with creatine ingestion. However, subjects who ingest creatine during resistance training are more consistent in demonstrating positive effects. It appears likely that creatine improvement in body weight and “swelling” of muscles.

Effects of Creatine Supplementation on Performance

It should be emphasized that many studies have not reported changes in performance for creatine supplementation alone (Lorenzo, 2002). In addition to the obvious implication that creatine alone can improve performance, these muscle specific findings have been attributed to factors such as increased muscle hydration and increased variability of muscle creatine increases following supplementation (Juhn et al., 1999; Stanton & Abt, 2000). However, these studies reported increased muscle creatine uptake or the ingestion of creatine with ~50 g of a carbohydrate beverage daily increased muscle total creatine by 9% more than ingestion of a carbohydrate beverage without creatine. The increase in muscle strength seen in subjects ingesting creatine during resistance training may result from creatine’s ability to enhance the energy production during exercise lasting 30 seconds or less. However, this cannot fully explain the large intersubject variability in creatine following creatine supplementation (adapted from Kreider et al., 2003).

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The greatest increase in muscle creatine following supplementation is seen when compared with subjects ingesting placebo. Moreover, increased muscle creatine content in creatine-supplemented athletes compared to placebo-supplemented athletes was most consistent during sprinting episodes within and at the end of certain prolonged events such as cycling races.

Effect of Creatine Supplementation on Exercise Performance

Sixteen of 21 studies that met criteria for inclusion and concluded that creatine was one of only two ergogenic supplements. Researchers studying potential adverse events associated with creatine supplementation based on the fact that creatine loading can improve performance in high-intensity exercise and the incidence of injuries observed over three seasons of collegiate football competition and an environment of year-round training.

Summary and Comment

Our overall conclusion is that the performance of some, not improve the endurance component of exercise performance. This finding suggests that creatine ingestion during resistance training may not prove ergogenic in longer exercise tasks given the relatively small contribution of phosphocreatine to energy production and the possibility that creatine supplementation might induce muscle dysfunction. Researchers studying potential adverse events associated with creatine supplementation based on the fact that creatine loading can improve performance in high-intensity exercise and the incidence of injuries observed over three seasons of collegiate football competition and an environment of year-round training.

SUMMARY AND COMMENT

Although meta-analyses have been conducted in an attempt to compile results of many studies in an unbiased manner, there are several limitations with this statistical approach. The data are often difficult to blind studies when subjects are known to ingesting creatine compared to placebo, one brief investiga-
Though not recommended, young athletes use creatine to increase muscle mass and strength. Rarely do they recognize that creatine supplementation may increase the incidence of cramping and injury. Though not recommended, young athletes use creatine to increase muscle mass and strength. Rarely do they recognize that creatine supplementation may increase the incidence of cramping and injury.

REFERENCES


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Creatine supplementation has been shown to improve performance of brief, high-power activities. Creatine supplementation may increase phosphocreatine resynthesis before PCr stores are depleted. Consequently, it has been hypothesized that people who increase their muscle creatine stores before PCr stores are depleted support this type of activity. In


When athletes consume creatine in their diets, whether from meat and fish or from creatine supplements, some of the creatine will be absorbed from the blood into the muscles. Once in the muscles, creatine can be combined with phosphate to form phosphocreatine, a vital—but very limited—source of energy for brief, high-power activities such as sprinting and resistance training. It follows that creatine users should have more phosphocreatine energy available to perform these kinds of activities, leading to improved performance.

This rationale for consuming creatine supplements sounds great, and many millions of dollars worth of creatine supplements are sold every year. But even after the completion of several hundred scientific investigations, many questions remain about the value of creatine supplementation for performance of various sports and about how much and when to use creatine—if it should be used at all. Here is some of what is known:

- Supplementing the diet with 20 grams of creatine daily (four 5-gram doses) for 4–5 days (i.e., “creatine loading”) will increase muscle levels of creatine in some, but not all, individuals. Doses of 5 grams raise blood creatine concentrations to the optimal amount that will maximize uptake of creatine into muscles. Creatine ingested in amounts greater than 20 grams per day will be wasted in the urine.

- Ingestion of 2 grams of creatine daily for 30 days takes longer but is just as effective as creatine loading for increasing the creatine concentration in muscle.

- Carbohydrates consumed with creatine supplements will increase creatine uptake by muscles compared to creatine supplements alone, but not by much.

- Creatine ingestion will likely increase body mass by a few pounds or kilograms, some of which will be extra muscle and the rest extra water. This weight gain could be detrimental in sports like running in which additional body weight may impair performance.

- Because creatine can make muscles appear larger by increasing the muscle uptake of water, it may enhance motivation to perform better and work harder in sports where increased muscle mass is desirable.

- Most laboratory studies of high-power tests lasting 30 seconds or less show slight, but potentially important improvements in performance in creatine users. A common example of such performance tests is repeated bouts of maximal cycling exercise, each bout lasting about 6–10 seconds.

- With laboratory performance tests that last between 30 and 90 seconds, the evidence for creatine effects on performance is predominantly positive, but is less persuasive than for activities lasting less than 30 seconds.
As test durations exceed 90 seconds, it is progressively less likely that creatine users will perform better than non-users (Table 1S).

<table>
<thead>
<tr>
<th>Performance Test</th>
<th>Evidence for Ergogenic Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intense Brief Exercise (Laboratory Tests; &lt;30 sec)</td>
<td>Convincing</td>
</tr>
<tr>
<td>Weight-lifting (when creatine is used concurrently with resistance training)</td>
<td>Convincing</td>
</tr>
<tr>
<td>Intense Exercise (Laboratory Tests; 30 sec to 3 min; intermittent effort)</td>
<td>Moderately Convincing</td>
</tr>
<tr>
<td>Convincing Intense Exercise (Laboratory Tests; &gt;3 min)</td>
<td>Not Convincing</td>
</tr>
<tr>
<td>Intense Exercise (Field Tests such as Swimming and Sprinting)</td>
<td>Not Convincing</td>
</tr>
</tbody>
</table>

When consumed in moderate doses, there seem to be no adverse effects of creatine supplementation in healthy adults.

Scientists do not know the effects of creatine supplementation on children who are still growing. Individuals younger than 18 years of age should not take creatine supplements.

Because the Food and Drug Administration does not tightly regulate supplements, there is no guarantee that all the ingredients in a product are stated on the label. There have been incidents where supplements are “spiked” with stimulants or prohormones that are banned by sport governing bodies.

Don’t count on supplements to make you a champion. Using any supplement, including creatine, can never take the place of hard training and skill practice, good nutrition, sound sleep, and ample rest.

**SUGGESTED ADDITIONAL RESOURCES**


