



# A Primer On Branched Chain Amino Acids

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Literature Education Series On Dietary Supplements

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## Introduction

**B**ranching chain amino acids have a non-continuous link of carbon bonds. Essentially having one carbon not in a linear fashion makes a branched point; all branched chain amino acids have one or more points of non-continuous links. (1,2)

Leucine, isoleucine and valine are the three branched chain amino acids. All three are essential amino acids the remaining five are phenylalanine, methionine, tryptophane, threonine and lysine. Some authorities suggest there is a total of ten essential amino acids including arginine and histadine. Other suggests that arginine and histadine are conditionally essential. Arginine is essential for children up to five years old, and the elderly, sixty and up. Histadine is essential for children up to five years of age. The branched chain amino acids make up 40% of the daily requirements of essential amino acids. (1,2) While the dose for leucine is approximately 40mg per kilogram of body weight per day, and isoleucine and valine are typically 10-30 mg per kilogram per day. (10)

At one point the safe levels or the R.D.A. for BCAA's were 20% of the total amino acids needed for daily needs. The established values for amino acid come from the FAO (Food and Agriculture Organization) and the National Research Council (NRC). The FAO and the NRC, who are often times concerned with the growth of infants and children. After closer evaluation of human needs the requirement of BCAA's went up

dramatically, to the current levels of 40%. A number of studies establishing levels for BCAA's involved individuals fasting and living normal lifestyle, not in quest of more muscle or energy. (3)

Athletes are commonly one of the primary groups using BCAA in supplemental forms. The changes in RDA levels and the BCAA's have changed dramatically in the last years. I wonder if athlete levels need augmenting as well.

## Metabolism of BCAA's

### General Metabolism

Proteins are the foundation of amino acids. In order to render amino acids form protein molecules proteins must be digested via the gastrointestinal tract, GI. This involves stomach hydrochloric acid secretion on large protein molecules, then pancreatic secretion of the protease breaking down longer amino chains, and finally the breakdown into smaller fragments in the small intestine to form free amino's and some small peptides with the enzyme peptidease. Most amino acids are then subject to transportation to the liver and some metabolism in the viscera (splanche) area and the stomach mucosal area. (4)

Free BCAA's are a little different in that they are directly transported to the bloodstream through the liver, while some exchange in the intestinal viscera and go directly to the bloodstream also. Most all amino acids can be degraded, broken down, in the liver effectively, with the exception of BCAA's. The liver oxidizes the BCAA's from their converted form called oxo-Keto acids. This means that basic BCAA's are not metabolized by the liver directly. Ultimately large percentages of the BCAA'S are oxidized by the muscle tissue and some by fat (adipose) tissue (5) The largest percentage of oxidation occurs in muscle tissue (Organ Specific Muscle)

The enzyme needed to catabolise or break down the BCAA's is called mitochondrail dehydrogenase and branched-chain keto acid dehydrogenase BCKADH. Keto acids can then be used by muscle to fuel the Krebs's cycle for ATP production or be transported to the liver for oxidation. Although this can occur in other tissue the dominant area of use is in the liver. The result of BCKADAH is BCOA, branched chain oxo acids, which can be used as energy in the liver. Keto acids of BCAA's inhibit this action, such as Alpha-Ketoisocaproic acid the transamination product of Leucine. Some supplement companies sell the Keto versions of the BCAA's. This can inhibit the breakdown of BCAA's as energy source. (6)(9)

In summary, BCAA's comprise approximately 35% of all muscle tissue. They are actively metabolized by muscle as energy, while the liver can use BCAA's as energy as well.

### Exercise and BCAA's

Six amino acids are taken into muscle tissue for energy including Alanine aspartate, glutamate, and the BCAA's. While the BCAA's have the greatest metabolic potential for energy use in muscle.

Muscle tissue has 60% of the specific enzymes needed for oxidation (burning) of amino acids for energy, specifically BCAA's. In essence muscle is designed to burn BCAA amino acids for energy. During exercise the body uses BCAA's as energy. The longer and harder the workout the more BCAA's are used in muscle for energy. It is estimated 3% to 18% of all workout energy is provided by the BCAA's, while some consider this to be conservative the duration and intensity levels can indicate greater or lesser amount of usage.

The bodies need for the BCAA especially, Leucine is 25 times greater than the free amino pool, or readily available leucine. The free amino pool is free or single amino acids found in skeletal muscle, blood and cell plasma. (75% is in muscle) Free amino acids are amino acids not bound just 'waiting' for use. Because of the great need for Leucine the body must catabolise or breakdown muscle for the Leucine needed during a workout. (7)

BCAA's can also be converted to alanine or glutamine in the muscle. Alanine and glutamine can go through glyconeogenesis in the liver to form glucose. Simply put, be converted to new glucose.

Ultimately leucine is one of the major 'foods' for muscle energy during workouts.

### Muscle tissue Synthesis and signaling effects of Leucine

Certain amino acids have a muscle tissue signaling effect on synthesis. Glutamine and leucine are in this category. Glutamine seems to have the largest response although ineffective if leucine is not present.

Leucine has a direct action on stimulation of protein synthesis with activation of insulin and cellular activation. Insulin increases the uptake of all amino acids into cells.

While the major destination for BCAA's is muscle tissue for energy, the incorporation of BCAA's into muscle is dependent on IGF-1. IGF-1 stimulates muscle tissue synthesis while insulin inhibits the breakdown of muscle and encourages the uptake of amino acids including BCAA's.

Chronic low levels of BCAA's will eventually show up in the urine and plasma resulting in loss of muscle mass and protein synthesis capabilities some times alopecia.(12) (14) (31)

### Supplemental Use of BCAA's

BCAA's when consumed in the free form, bypass the liver and gut tissue and go directly into the blood stream. Supplemental free forms quickly elevate the blood supply and affect circulating BCAA levels. This is especially true when there are low levels of glycogen or stored sugars. (8)

BCAA's supplements have shown beneficial effects when taken before and after workouts. While large dosages of single leucine are not recommended by some authorities, the use of BCAA's might be best in combination. (12)

### Endurance and Fatigue

Prevention of fatigue and BCAA's with athletes occurs in two primary ways. First, the loss of ATP or cellular energy occurs with the loss of stored glucose in the form of glycogen. ATP levels are maintained by BCAA's degradation and fatty acid utilization after glycogen depletion. The effect of BCAA's as energy is approximately 3-18% and possibly more depending on duration and or intensity of the workout. Muscle tissue can oxidize leucine for energy or convert leucine into glutamine or alanine for blood energy. Glutamine or alanine can be converted into glucose. Also isoleucine and valine can be converted to Krebs cycle components for energy as well; making all three BCAA's a valuable source of muscle energy.

The second primary fatigue fighter for BCAA's is seen with BCAA's ability to prevent central fatigue in the nervous system. Central fatigue happens with the uptake of tryptophan by the brain increasing the levels of serotonin. Serotonin increases tiredness and fatigue demanding reset. BCAA's inhibit the brains ability to uptake tryptophan decreasing the brain levels of tryptophan. BCAA's do prevents sleep apnea in normal adults. (12)

For endurance athletes the use of BCAA's before and after the workout has shown to be effective in reducing total time for events. Cyclist and marathoners have shown positive effects when using BCAA's immediately before events and during an event. Improvements in mental performance and reduction in times have been noted. The reduction of lactic acid levels have been shown in some studies (reduced burn). Muscle mass loss has been shown to be reduced also. Two weeks of supplementation has shown improvements in time-trial cyclist, with trained athletes. It is also noted that some studies indicated no improvements.

Some studies have compared BCAA's to glucose, while some formulas today have the two together.

Dosage 3-20 grams a day, taken before during and after workouts. Most studies indicated 7 to 12 grams during long events mixed into carbohydrates solutions. (13) (39)(40)(41)(42)(43)

### Muscle Building and BCAA's

Recovery from a workout as well as increased energy can be accomplished with BCAA's use.

During exercise times when muscle contacting tissues are being degraded for energy non contractile muscle proteins decrease in catabolism, and inversely with reduction of exercise. In addition the breakdown of contractile tissue increases during post work recovery. So increasing the usage of BCAA's before and especially after workouts has been a norm for years producing a 'muscle sparing' effect. In addition the stimulation of muscle synthesis and the use of BCAA's have required large dosages of these three amino's. Although most research points to leucine as the amino that stimulates this action in supplementation and meal situations. (15) (25)

### Recovery

BCAA's have been used for recovery extensively. Exercise recovery and the degradation of proteins are reduced with the use of BCAA's and especially leucine. As noted above leucine has a signaling effect on key enzymes for protein synthesis having an anabolic effect on human muscle. BCAA's usually are coupled with

insulin and IGF-1, although BCAA's have a direct action on muscle tissue synthesis without insulin. This might be helpful in individuals with insulin problems looking for muscle stimulation.

### Muscle tissue gains

One study used approximately 3400 mg of leucine for a 170 pound man for recovery and tissue synthesis for lean individuals needing to build muscle. This study used whey protein mixed with the extra leucine. The diet consisted of 55% carbs and 15% proteins with added leucine spread throughout the day. Another study indicated the use of BCAA's, with approximately 50% leucine as the base with whey proteins at 1.26 grams per kilo which is about 107 grams per 170pound individual. Here is a snap shoot of dose per weight and individual body weight.

Body weight in Pounds	BCAA's total grams	Proteins total grams.
150	5650mg.	94grams
170	6400mg	107grams
200	7500mg	125grams
250	9400mg	156grams
300	11300mg	187grmas

Many authorities agree that proper protein supplementation should be at 1.3-1.6 grams per kilogram of body weight daily for strength training athletes.

Finally some good studies indicated 5.6 grams of BCAA's two times a day improved weight lifting recovery and improved muscle stability. Another study indicated 3.6 grams two times a day improved the recovery of rugby player. Ultimately the dosage above should be a good rule of thumb. (18)(19)(20)(21)(41)(48)(49) (50)

### Fat Loss

Recent research has confirmed leucine increases the adipocytes (fat cells) release of fats for energy. In addition leucine has shown to be a factor in prevention of muscle tissue degradation during dieting in diabetic situation. Most dieting situation increases the loss of lean tissue and increase muscle loss. Having adequate leucine and protein will prevent the loss of muscle during dieting. (26) (27) (34)

## Summary

Food sources for BCAA's are: whey, and milk proteins, beef, chicken, fish, soy proteins, eggs, baked beans, whole wheat, brown rice, almonds, brazil nuts, pumpkins seeds, lima beans, chick peas, cashew nuts, lentils, and corn.

Higher Dosages of BCAA's studies done with rats in excess of 15 grams per kilo gram of body weight have shown to decrease B3 blood and tissue levels. For a 100 pound man that would be about 750 grams. Based on the dosages as listed above it is always good to make sure you have enough of the b-vitamins in your supplement program.

Although one study in animals with extremely high dosages was found to be problematic, there is no correlation toxicity with human studies. Acceptable dosages seem to be around 4-20 grams depending on body weight and event of use.

BCAA's research and use in supplementation has been going on for many years. Many studies indicating the mechanisms of action on human and animal anatomy have been done. More research needs to be done. It is noted that there are some authorities that believe the use of BCAA's for energy, recovery; muscle synthesis and stamina are not conclusive enough. While current studies have been substantial proving the effects of BCAA's.

BCAA's are safe and pose no threat when used appropriately. Further investigation and more research will undoubtedly happen with dosage and timing which should substantiate the effectiveness of BCAA's.

Finally BCAA's are muscle tissue specific providing energy during workouts and muscle tissue stimulation and recovery when consumed after workouts or events in either food or supplement form. BCAA's can be used before and after workouts for increased energy, muscle sparing action, recovery, and muscle tissue stimulation and stability. (22) (29) (30)

### BCAA's and Disease

BCAA's oxidation has been shown to increase in cancer, AIDS, diabetes and other muscle wasting diseases.

The use of BCAA's in one study with liver cancer patients while going through liver reconstruction and chemo-emobilization seem to show some benefit. While some recent trials suggested that clinical metabolic parameters, morbidity and quality of life was improved with oral BCAA usage. At this point the use

of BCAA's is clearly undefined and remains to be unclear, despite the potential benefits.

Other liver studies with 7 individual's age over 70 with cirrhosis used 4 grams BCAA's with each meal. Results suggested that blood proteins (albumin) were increased.

Diseased liver studies have shown benefits with BCAA's, dosages and information should be used with a qualified physician. The use of BCAA's in conjunction with disease should be done with your physician consultation. (15) (34)(35)(44)(45)(47)

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