THE ANABOLIC, ANTI-CATABOLIC/FAT LOSS PROPERTIES OF LEUCINE

Contributed by Robbie Durand
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The Justice League is composed of a bunch of jacked up super heroes each with special powers put together to fight crime and maintain order. Each member of the Justice League plays his role but the league is centered around one superhero, Superman. The amino acids are just like the Justice League they are there to build muscle and fight the bad guys (cortisol, myostatin, muscle atrophy, ect). If there is one amino acid that stands out and is more powerful than any other amino, Leucine is the Superman of the amino acids. Several studies published this month documents leucine has both the ability to increase muscle growth and lose bodyfat. Obviously, all amino acids are required to make proteins, but remarkably a large dose of leucine alone can stimulate human muscle protein synthesis1. In fact, it has been reported that muscle protein synthesis responds linearly to plasma concentration of leucine14. In other words, the more leucine you consume, the greater the muscle protein synthesis rates. In this months Journal of Molecular Reproduction and Development, leucine does a whole lot more than just stimulating protein synthesis, it activates satellite cell activity. When muscles undergo intense exercise, as from a resistance training bout, there is trauma to the muscle fibers. This disruption to fibers activates satellite cells, which are activated to the injury site. In essence, a biological effort to repair or replace damaged muscle fibers begins with the satellite cells fusing together and to the muscles fibers, often leading to increases in muscle fiber hypertrophy. It has previously been documented that resistance exercise stimulates satellite cell activity; it is also well documented that insulin-like growth factor-1 (IGF-1) stimulates satellite cell activity. Leucine has some similarities to IGF-1 as both IGF-1 and leucine increase muscle size by stimulating mTOR signaling in skeletal muscle. Researchers examined the effects of adding either leucine or IGF-1 to muscle satellite cells and found that both IGF-1 and leucine upregulated mTOR signaling in satellite cells8. In addition, there was no difference between IGF-1 and leucine for increasing satellite cell activation. Activation of mTOR signaling is necessary for the protein synthesis in satellite cells stimulated by IGF-1 and leucine. This study was performed with muscle cell in test tubes but it makes you wonder could large dosages of leucine be just as effective as IGF-1 for stimulating muscle growth? Adding a few scoops of leucine powder to your protein/carbohydrate beverage may increase the anabolic drive in muscle. The coingestion of leucine (1 gram per kg of bodyweight) and protein with carbohydrate has been found to increased whole body protein synthesis compared with a combined ingestion of carbohydrate and protein. Interestingly, the combined ingestion of leucine and protein with carbohydrate may enhance IGF-1 levels as the insulin response of leucine, protein, and carbohydrates rose by ~250% compared with the ingestion of only carbohydrate25. Adding some leucine to your post exercise drink may be the missing ingredient to enhance muscle growth.

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Leucine: A Fat Loss Agent?

You have heard of myostatin knockouts mice, well get ready for the new genetically altered super leucine mouse. Scientists disrupted the branched chain aminotransferase gene, which is the enzyme which breaks down BCAA in muscle. In essence, the mice have genetically elevated levels of leucine. So is there anything unusual about these super leucine mice? What interesting is that these mice exhibit elevated plasma BCAA’s but also decreased adiposity, despite eating more food, along with increased energy expenditure, remarkable improvements in glucose and insulin tolerance, and protection from diet-induced obesity12. High dosages of leucine may be the able to prevent excess fat gain in the offseason when calories are high. Another article of interest was published in the journal of Diabetes in which they fed rats a high fat diet but also doubled their leucine intake by adding it to their drinking water. Even though the rats ate the exact same calories on the high fat diet increasing leucine intake resulted in up to 32% reduction of weight gain and a 25% decrease in adiposity. The reduction of adiposity resulted from increased resting energy expenditure associated with increased expression of uncoupling protein 3 in brown and white adipose tissues and in skeletal muscle10. Consider being like a rat for a while during the weeks leading up to the competition and adding leucine to your water supply. The final article of interest was published in Journal of Life Sciences which they took rats and put on leucine and phenylalanine and then put them on a calorie restricted diet by 50% for 1 week. The scientists then let the rats eat whatever they wanted for 2 weeks after that. Compared to the group of rats that received nothing, chronic supplementation with leucine and phenylalanine was able to improve the body composition by increasing lean body mass and by reducing, although modestly, the accumulation of body fat11. This means that bodybuilders may be able to prevent putting on excess bodyfat after dieting for a competition by taking leucine. So based on these studies, bodybuilders should be taking leucine especially during the competition phase to reduce bodyfat but also stimulate protein synthesis rates. I even suggest adding it to your drinking water like the lab rats!!!

Leucine can substitute for a complete protein meal

For several years taking branched chain amino acids were advocated pre-workout, but taking leucine may be the only amino acid necessary as muscle protein stimulation is responsive to stimulation by leucine, but not the other branched-chain amino acids, isoleucine and valine13. Leucine seems to be the most potent of the BCAA with regard to most of these effects and therefore may be the most physiologically relevant. Leucine alone can substitute for a meal in stimulating signal transduction pathways, leading to a stimulation of protein synthesis. Large oral leucine dosages increased muscle protein synthesis within 20 min. similar to meal feeding; the activity of the mTOR-signaling pathway in muscle is augmented following the oral leucine consumption. So when getting ready for a show, consuming extra leucine can enhance protein synthesis.

Leucine Increases Protein Synthesis Independent of Insulin

Leucine has both anabolic effects in skeletal muscle reflecting both stimulated protein synthesis and inhibited protein breakdown. Studies suggest that some of the anabolic effects of leucine are regulated by mechanisms similar to those regulating the effects of insulin20, 21. Leucine is now known to interact with the insulin-signaling pathway with apparent control of protein synthesis, resulting in maintenance of muscle protein during periods of restricted energy intake. Leucine appears to also stimulate protein synthesis independent of insulin17. For example, a dosage of leucine resulted in a stimulation of protein synthesis that was independent of changes of plasma insulin concentrations, whereas a dosage containing carbohydrates (glucose plus sucrose) that raised insulin concentrations over 2.5 times the fasting glucose concentration did not affect protein synthesis3. Overall the results demonstrate that leucine can cause increases in protein synthesis rates that are independent of insulin.

Anti-Catabolic Actions of Leucine

Oral intake of leucine stimulates muscle protein synthesis after exercise or an overnight fast18, 19. These studies support the role of leucine as a key amino acid for reversing catabolic conditions which may be especially important when trying to get ripped for a competition In previous studies, there is evidence that catabolic conditions, muscles tissue becomes resistant to some of the anabolic effects of leucine22, and it is possible that this “leucine resistance” reflects why cortisol breaks down muscle tissue. More recent studies from laboratories provided direct evidence for a role of cortisol in “leucine resistance” in skeletal muscle. For example, Shah et al.6 reported that cortisol opposes the control of protein synthesis by leucine in skeletal muscle. Additionally, Rieu et al. 7 examined the effects of cortisol in young (4–5 wks), adult (10–11 months), and old (21–22 months) rats and made the interesting observation that cortisol induced leucine resistance in adult and old rats, but not in young rats. Considering those findings, the authors speculated that muscle loss during aging may reflect cortisol- induced “leucine resistance.” This may be the reason why you do just about anything in the gym and still grow however with aging the gains are not as apparent. Fasting and calorie restriction also results in an increase in leucine appearance rate in the blood, an index of whole body protein breakdown. The increase in leucine appearance is consistent with a decline in insulin, because insulin normally suppresses protein breakdown. Additionally, fasting increases the hormone glucagon which has a catabolic effect on leucine23. In skeletal muscle, exposure to cortisol is characterized by a reduction in protein synthetic rate coincident with hampered protein synthesis rates; however oral administration of leucine reversed the catabolic effects of with a 1 hour of administration24. It seems that intense training and calorie restriction both increase cortisol however leucine seems to counteract the negative effects of cortisol.

Older Bodybuilders May Need More Leucine than Younger Bodybuilders

Older bodybuilders are becoming more and more common these days. In general, aging is associated with a decrease in protein synthesis which has been termed "anabolic resistance." This is shown by a decrease sensitivity and responsiveness of protein synthesis in muscle in both rats and humans. The leucine signal is also observed to be less sensitive in older subjects15. In one study, leucine concentrations 1–2 times greater than in young animals were necessary to observe the same changes in older rats. This suggests that the defect in postprandial muscle protein anabolism in old subjects is related to the alterations of the leucine signaling in muscle. However, the molecular mechanism responsible for the blunted signaling pathways for leucine remains unresolved. Interestingly, a recent study reported that when comparing younger (8 months old) and older rats (22-months-old) protein breakdown rates; the rates of protein breakdown were higher in older rats compared to younger rats, but when older rats are fed a diet which is supplemented with 5% Leucine, there is a rejuvenation of muscle and an inhibition of protein breakdown similar to young rats16. Based on the research in old rats and humans, high concentrations of leucine appear capable of stimulating muscle protein synthesis to the same degree as physiological concentrations in younger subjects. Thus, aging seems to be associated with a decrease in leucine-induced stimulation of muscle protein synthesis. The long-term utilization of leucine-rich diets may therefore limit muscle protein wasting during aging.

It seems that taking leucine in large dosages not only increases protein synthesis rates, activates satellite cells, reduced the catabolic actions of cortisol, and reduces bodyfat. The good news is that leucine is among the most tolerated amino acids as no adverse effects of increased leucine intake (usually 3x of the daily requirement) were reported in various human studies9. Leucine is clearly the most potent anabolic amino acid on the market today.

Key Points:

• Leucine alone increases protein synthesis independent of insulin

• Leucine had potent fat loss properties

• Leucine has both anabolic and anti-catabolic actions

• Leucine synthesis is decreased with age

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