Factors Affecting Muscle Mass

The factors underlying variations in protein synthesis and catabolism, which regulate muscle mass, are complex and still being worked out. However, we have enough information now to allow us to manipulate both processes and increase muscle accretion.

While difficult to understand, and even tedious at times, the principles behind the regulation of protein metabolism are worth knowing about since they underlie much of what we do in our attempts to maximize body composition and exercise performance.

For example, amino acids, while important as substrates for various metabolic pathways, are also regulators of protein synthesis and other metabolic processes.

We know that like exercise, amino acids increase protein synthesis with the signaling pathways influencing mTOR (mammalian target of rapamycin), which in turn stimulates protein synthesis.[1,2]

Accelerated protein breakdown and a net protein loss occur secondary to exhaustive exercise and in injury and various diseases. The negative nitrogen balance observed in such cases represents the net result of breakdown and synthesis; with breakdown increased and synthesis either increased or diminished. Under certain conditions protein catabolism can also be decreased. As well, protein synthesis can be increased or decreased under certain conditions. The net result depends on the conditions present and the effects on both synthesis and catabolism.

For example, in order to have a net increase in protein synthesis so that there is an increase in the concentration of a protein in a cell, its rate of synthesis would have to increase or its breakdown decrease or both. There are at least four ways in which the concentration of protein in a cell could be changed:

1. The rate of synthesis of the mRNA that codes for the particular protein(s) could be increased (known as transcriptional control).

2. The rate of synthesis of the polypeptide chain by the ribosomal-mRNA complex could be increased (known as translational control).

3. The rate of degradation of the mRNA could be decreased (also translational control).

4. The rate of degradation of the protein could be decreased.

The following table outlines some of the conditions or factors affecting protein synthesis. Many of these conditions and factors are inter-related. Keep in mind that protein synthesis is increased as the result of a net positive change secondary to changes in both (or less commonly one of) synthesis and catabolism.

Table 1 -

Some conditions and factors affecting protein synthesis:**

Conditions or Factors:	Effect on rate of protein synthesis:
Decreased protein intake	decreased
Increased protein intake	increased
Decreased energy intake	decreased
Increased cellular hydration(i)	increased
Decreased cellular hydration	decreased
Increased intake of leucine in presence of sufficiency of other amino acids	increased
Increased intake of glutamine in presence of sufficiency of other amino acids	increased
Lack of nervous stimulation	decreased
Muscle stretch, or exercise	increased
Overtraining	decreased
Testosterone (and anabolic steroids)	increased
Growth hormone	increased
Insulin-like growth factor one (IGF-I)	increased
Normal thyroid hormone (ii)	increased
Excess thyroid hormone	decreased
Catecholamines (including synthetic ß-adrenergic agonist such as clenbuterol)	increased
Glucocorticoids	decreased
Physical trauma, infection	decreased

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i. Cellular hydration refers to an intracellular state and as such is different from extracellular hydration.

ii. Thyroid hormone (thyroxine and triiodothyronine) stimulate both protein synthesis and degradation depending on their levels in the body. Not enough or too much can be detrimental to protein synthesis. Higher than normal levels of thyroid hormone leads to the catabolism of protein.

** From Amino Acids and Proteins for the Athlete, the Anabolic Edge, Mauro Di Pasquale, M.D., 2nd Edition in Press.

The amount of protein synthesis that takes place during and after exercise is dependent on several factors including a complete complement of precursor amino acids (both essential and non-essential amino acids), specific acetylating enzymes, tRNA, and adequate ATP levels. While the relation of protein synthesis to the ambient concentrations of amino acids in the intracellular and extracellular pools has not been fully defined, it is possible to identify sets of intracellular amino acids that predict the level of protein synthesis, and to delineate combinations of plasma amino acids whose levels account for a significant portion of the variance in the intracellular predictor amino acids in normal human infants and adults.

In one study the intracellular concentrations of most amino acids were found to be higher than their concentrations in plasma, except for valine and citrulline, which were lower.[3] The "aminograms" in the two pools also were very different - 44% of the variance in protein synthesis was accounted for by the intracellular concentrations of leucine, glycine, alanine, and taurine in neonates, and 45% by a combination of threonine, valine, methionine, and histidine in adults. The intracellular concentrations of each of these predictor amino acids in adults were, in turn, related to different combinations of the plasma concentrations of threonine, phenylalanine, tryptophan, isoleucine, histidine, citrulline, ornithine, arginine, and glycine.

The increases in intracellular amino acid concentrations seen with exercise may reflect decreased protein synthesis, accelerated protein catabolism, an increase in amino acid transport into the cell, or combinations of these conditions. For example an increase in protein synthesis would be expected to cause a decrease in amino acids but this may be offset by an increase in intracellular availability due to increased transport. As well, altered intracellular amino acid levels may directly regulate exchange diffusion of intracellular for extracellular amino acid(s).

Effects of Exercise on Protein Synthesis and Degradation

Acute bouts of exercise can induce measurable changes in protein, carbohydrate, and lipid metabolism. These changes are characterized by a change in protein catabolism and synthesis and an increased utilization of protein for gluconeogenesis and lipids for oxidative fuel.[4,5,6,7] Chronic daily exercise leads to adaptive processes that result in a net increase in total body as well as peripheral nitrogen stores.[8]

Exercise has profound effects on protein synthesis and degradation, and on the endogenous anabolic and catabolic hormones, which in turn modulate the adaptation response to exercise.[9,10,11,12,13,14,15,16,17,18,19,20] In general protein synthesis is suppressed during exercise while protein degradation appears to be increased; while in the recovery period during which hypertrophy occurs, protein synthesis is increased while protein degradation is suppressed in those muscle bearing the greatest load.[21,22,23,24,25,26,27]

Shortly after training protein synthesis increases with a peak in synthesis rate of between 3 to 24 h, with elevated rates lasting as long s 48 to 72 hours after exercise.[28,29,30,31,32,33.34,35]

Effects of Protein and Amino Acids on Exercise Performance

An increase in protein intake by itself has been shown to not only increase protein synthesis and decrease muscle breakdown, but has also been shown to increase both aerobic and anaerobic performance.[36,37,38,39]

Amino acid supplementation can have dramatic effects on various aspects of exercise, increasing protein synthesis and/or reducing degradation, and has been shown to attenuate muscle damage and enhance recovery.[40,41,42]

Data from one study showed that amino acid supplementation attenuates muscle damage during the initial high stress of overreaching, and the authors felt that this effect may partially explain the enhanced ability of the subjects to maintain muscle strength.[43]

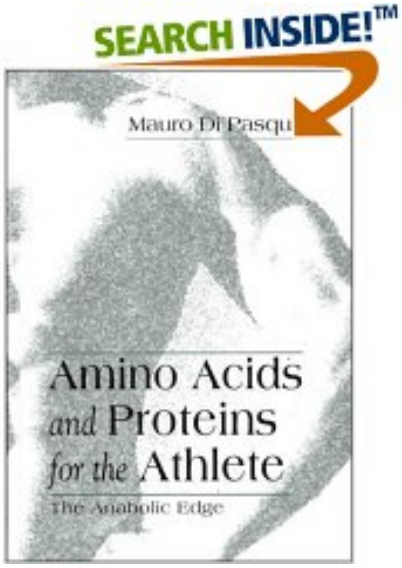
Oral or infused amino acids increase amino acid availability and protein synthesis by influencing several pathways. Amino acids are important intermediary metabolites and also function as signaling molecules with insulin-like effects. For example, supplementation with only 6 g of essential amino acids has been shown to elevate protein synthesis.[44]

Branched-chain amino acids have been shown to reduce proteolysis in rat skeletal muscle[45] and leucine has been shown to elevate protein synthesis via posttranscriptional mechanisms (phosphorylation of $p70^{S6}$ and eIF4E-binding protein 1).[46]

More Information

It would take a book to present a comprehensive overview of the uses of amino acids and proteins for body composition, strength and performance. And in fact I did write a book back in 1997 on the subject, and just finished writing the second edition of the book.

Amino Acids and Proteins for the Athlete - The Anabolic Edge (Nutrition in Exercise and Sport) (Hardcover)



Amino Acids and Proteins, 1997 Edition

The Second Edition to my Amino Acids and Proteins for the Athlete, published by CRC Press is in production and will be available later this year.

The new edition, at over 400 pages and with almost 3300 references is a major update to the first edition.

For a view of the first edition, published a decade ago, go to http://www.amazon.com/Amino-Acids-Proteins-Athlete-Nutrition/dp/0849381932

My Amino Acids and Protein Products

All my knowledge and expertise on proteins and amino acids has gone into formulating my supplement line, including **Amino**, **Myosin Protein**, **Power Drink**, **Creatine Advantage, and MRP LoCarb**.

I also make extensive use of amino acids in several of my other supplements, including the new ThermoCell 35. For details on one or all of my supplements look up the detailed PDF files in my store www.MDPlusStore.com

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