The Influence of Protein, Amino Acids, and Beta-hydroxy-beta-methylbutyrate (HMB) Supplementation With Strength Training and Muscular Development

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This presentation examined some of the important concepts of protein, amino acids, and beta-hydroxy-beta-methylbutyrate (HMB) on strength training and muscular development. One of the primary variables that is enhanced with strength training and supplementation with these nutrients is lean body mass (LBM), which is commonly defined as everything but the essential body fat component.[1] The target for strength training is primarily skeletal muscle and connective tissue (eg, bone, ligaments, and tendons).

The loss of the LBM component can affect both function and health. Under normal conditions, one sees a loss of LBM with aging, improper diet, inactivity, and in athletes, extreme overtraining.[2] Pathological conditions such as cancer and HIV can lead to the loss of LBM due to muscle wasting, as can surgical recovery and repair. Interestingly, strength training and/or supplementation programs and strategies have been shown to offset these conditions.[3] Therefore, a dynamic balance exists between the anabolic signal (to build) and the catabolic signals (to breakdown) in the process of either gaining or losing LBM.[4] These signals to both fat cells and skeletal muscle are regulated by hormonal signals from growth hormone (GH), testosterone (T), insulin-like growth factor-I (IGF-I) and insulin (INS), which produce anabolic signals to muscle and catabolic signals, for the most part, to fat cells.[5-7] If too much carbohydrate is ingested, INS can inhibit lipolytic enzymes and thus promote fat cell anabolism.[8] Cortisol is

one of the more prominent catabolic hormones to target both muscle and fat cells. For steroid hormones such as C and T, direct interactions with regulatory elements in the DNA in the cell's nucleus provide for a dominant direct effect on message signaling.[9]

Differently, peptide hormones (INS, IGF-1, and GH) all stimulate what are called secondary messenger systems or signaling cascades (eg, Janus kinase–signal transducer and activator of transcription [JAK-STAT] for GH or protein kinase AKT-mammalian target of rapamycin [AKT-mTOR] for IGF-1) to impart their message on the DNA machinery.[4] Nutritional signals (from, eg, amino acid and leucine) can by themselves stimulate the same signal system as IGF-1, and other nutritional macronutrients can affect anabolic hormones as well.[1] Finally, exercise also can stimulate autocrine hormones and molecular signaling cascades. Therefore, hosts of different signal cues to different target cells are diverse and complex and create what is called a "signaling web."[1]

Ultimately, we must realize that the control of this signaling web is dictated by what are called "upstream regulatory elements." In the case of human beings, specific exercise programs, nutrition, environment, and psychology all have an impact on what happens "downstream"as to the needed support and response of physiological systems, tissues, and resulting protein synthesis or degradation of target cells. Not all strength training programs are the same.[2,10] Strength training program stimuli are dictated by choice of exercises, order of exercises, amount of resistance, number of sets or volume of work done, and rest between exercises and sets. Various combinations can be designed to promote strength, power, hypertrophy, and/or local muscular

endurance. Protein, amino acid, and HMB supplementation can also augment or synergize with the effects of training depending on the amount and timing of the supplementation.[11,12]

The ingestion of protein increases muscle protein synthesis proportionally to the concentrations of essential amino acid present in the protein used.[13] Of 23 amino acids, 9 are classified as essential amino acids in that they must be obtained from nutritional intake or from non-essential amino acids that can be synthesized by the body. Branched-chain amino acids (BCAAs) isoleucine, valine, and leucine are essential amino acids with aliphatic side-chains that are non-linear. BCAAs, most prominently leucine, can influence muscle protein synthesis signaling directly.[4] HMB is a metabolite of leucine that is synthesized in the human body.[14] HMB plays a part in protein synthesis by interacting with mTOR in stimulating protein synthesis and with other pathways to reduce proteolysis, inflammation, and degradation of proteins.

Research has shown that the timing of protein and amino acid supplementation is important to optimizing protein synthesis.[15] Amino acid and protein supplementation before exercise appears to yield a higher value for protein synthesis than ingestion after the exercise bout.[16] Research has also shown that athletes may need a higher amounts of protein (1.4-1.7 g protein • kg^{-l} l day^{-l}) in their diets than non-athletes to deal with repair and remodeling of tissues; excessive amounts of protein (2.4 g protein • kg^{-l} l day^{-l}), on the other hand, are just oxidized in metabolism.[17] However, the composition of the exercise training program and its intensity dictate differential protein needs.[1,18]

Amino acid and HMB supplementation have been shown to reduce the amount of damage with exercise and decrease muscle soreness in some cases.[11,12,19] Supplementation with amino acids and protein, as well as with HMB, has been shown to enhance LBM, which in turn has resulted in increased performance measures for strength and power.[11,20,21] The mechanisms by which this occurs are diverse and related to the biochemical pathways that operate for each supplement and the training protocols used. Larger LBM gains have been seen with all such supplements in non-athletes, who have a larger "gain" window for LBM, strength, power, and endurance.[12] Future studies will have to focus on how each of these supplements can be effective in providing augmentation to tissue repair with aging, surgical recovery, and performances.

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