

Supplement: Protein Metabolism in Response to Ingestion Pattern and Composition of Proteins

Introduction

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The metabolism of protein and amino acids is influenced by multiple intrinsic and extrinsic factors. Dietary parameters that affect the response to protein or protein-containing meals include composition of the specific protein, meal composition (nonprotein nutrients) and amount or dose of the protein or amino acids ingested. Dietary protein handling is further influenced by timing of ingestion as well as the nutritional and physiological status of the individual. A symposium was organized to discuss advances in our understanding of basic protein metabolism in vivo, distinctions in the metabolic response to protein or amino acid compositions and different patterns of ingestion, and the implications of these different responses.

Our understanding and quantification of these processes have advanced significantly as the tools and methodologies to assess protein metabolism in vivo have become increasingly sophisticated. Studies at the whole-body and tissue level using steady-state isotopic techniques allow assessment of whole-body retention of dietary nitrogen and insight into tissue-specific handling of protein. Dual tracer techniques enable better understanding of the metabolic fate of dietary amino acids. The response to amino acid ingestion is fairly well defined relative to metabolism of intact proteins. Amino acid solutions are easy to manipulate in terms of dose and composition and, before the introduction of intrinsically labeled proteins, presented fewer problems methodologically.

The role of amino acids in regulating muscle protein metabolism has been described using arteriovenous balance techniques in conjunction with stable isotope tracer methodology. Amino acids regulate net muscle protein balance directly such that increases in extracellular amino acid concentrations serve as signals to activate the synthetic process, whereas a decline in concentration decreases synthesis.

The latency and duration of amino acid stimulation of muscle protein is characterized by a rapid rise in synthesis as amino acid concentrations increase. The response is time dependent such that the system appears to become refractory to the stimulatory effect after 2 h of constant elevation of amino acid concentrations. The rise in muscle protein synthesis occurs relatively quickly after the change in concentration and correlates strongly with the extracellular concentration, suggesting that signaling occurs to increase utilization of intracellular amino acids for protein synthesis. Just as there is a limit to the duration of the response, there is a ceiling to the dose response in that very high levels of amino acids (beyond physiological) do not linearly increase muscle protein synthesis. Whereas some studies at the whole body level suggest that the acute anabolic response to

supplementation is counterbalanced by a diminished synthetic response at a later time, peak elevations in muscle protein synthesis are, in fact, additive to 24-h net muscle balance.

In contrast to the rapid absorption and delivery after ingestion of free amino acids, intact proteins are digested at variable rates, a factor that appears to independently regulate postprandial protein gain. Whey proteins, for example, are rapidly digested and stimulate amino acid oxidation and protein synthesis but have minimal or no effect on proteolysis. In contrast, casein is more slowly absorbed and consequently inhibits breakdown while increasing amino acid oxidation and protein synthesis to a lesser extent. These observations may have practical implications, but at a minimum they illustrate an important methodological consideration. Steady-state approaches to measure postprandial protein metabolism necessitate feeding small, intermittent meals to maintain a constant pool size. Realistically, food consumption patterns result in more acute transient elevations in substrates and hormones, and we can predict the difference in the anabolic effect from observations of protein digestion rate and the role of magnitude and duration of change in amino acid availability.

These differences are further modified by the presence of nonprotein nutrients in the meal as well as factors external to the food source such as age or metabolic stress. Age-dependent responses are described for feeding patterns in that a single large meal versus several smaller meals results in an improvement in nitrogen balance in elderly volunteers, whereas young volunteers may have a better nitrogen balance when meals are spread out over time. In the context of exercise, timing of ingestion relative to the performance of exercise is important in that ingestion before exercise results in greater net muscle protein balance during the recovery period from exercise compared with when amino acids are taken after resistance exercise. Composition, amount and pattern of ingestion also influence the overall protein metabolic response at rest and in the context of metabolic stress such as exercise. Independent and interactive responses to protein nutrition and exercise also appear to differ between young and old, perhaps related in part to changes in endocrine function.

The articles contained herein reflect the content of the presentations by Daniel Tome, Ph.D., Robert R. Wolfe, Ph.D., Michael Rennie, Ph.D. and Bernard Beaufre, Ph.D. in the session titled "Protein Metabolism in Response to Ingestion Pattern and Composition of Protein," Nutrition Week 2002. As a whole, they provide a comprehensive overview of the developments in studying protein metabolic responses to dietary proteins and amino acids and the principle findings based on these techniques.