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Whey Protein- The Role of Protein Supplementation in Resistance Training

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INTRODUCTION

The U.S. recommended dietary allowance (RDA) for protein intake is 0.8-1.0 g of protein per kilogram of body weight per day for normal, moderately active people (1). However, most athletes tend to think that they require higher amounts of protein in their diet and will consequently consume various forms of protein supplements, providing them with protein intakes that are several times higher than the USRDA. One such supplement is whey protein, which is generally sold as a powder than can be mixed with water or in a shake. Most whey protein formulations contain a number of different proteins as well as significant concentrations of branched-chain amino acids (BCAAs: valine, leucine, isoleucine). Like most other protein supplements, whey protein powders claim to promote the maintenance of positive nitrogen balance in athletes. This essentially means that there is net storage of amino acids, and levels of muscle protein synthesis are maintained above levels of protein breakdown. This would result in increased retention and augmentation of lean muscle mass. This is one of the most important goals for resistance athletes. Therefore, it is critical to not only examine the scientific validity of these claims, but also to determine the effectiveness of whey as a supplement compared to other forms of protein.

PHYSIOLOGY

Amino acids play a vital role in body metabolism during exercise, not only as sources of fuel but also as gluconeogenic precursors. During exercise, the body diverts energy away from most anabolic processes in order to support muscle activity. While carbohydrates serve as the main source of energy during exercise, amino acids from muscle proteins can also be utilized as a fuel source via gluconeogenic and catabolic processes, particularly during prolonged or especially strenuous exercise. All of these processes reduce the availability of amino acids for protein synthesis during and after exercise. As a result, after an exercise bout, the body is in a state of negative nitrogen balance, meaning more protein has been broken down than has been synthesized. Studies have demonstrated that muscle protein breakdown can be elevated for up to 48 hours after intense resistance exercise (2).

Upon entering the period of recovery, the body slows catabolic processes and is in a primed state for synthesizing lost substrates, including protein. Studies have shown that the rate of muscle protein synthesis increases after higher intensity resistance exercise, and remains above basal for up to 48 hours postexercise (3). However, without nutrient intake, breakdown continues to surpass synthesis and the body remains in negative nitrogen balance. When an individual consumes protein, whether in a supplement such as whey or in food, the ingested amino acids are carried through the circulation and can be transported to the amino acid pool in skeletal muscle, where protein synthesis can proceed. Presumably, a state of hyperaminoacidemia in the body would induce greater increases in protein synthesis and positive nitrogen balance because of the higher availability of substrates.

The high provisions of BCAAs in the whey protein supplements also reflect the increase in BCAA oxidation rate in skeletal muscle that occurs in response to exercise. BCAAs are valuable sources of carbon skeletons for oxidation as well as nitrogen residues for alanine formation, which helps maintain glucose homeostasis. Together the BCAAs account for about 20% of the protein that is broken down from muscle (1). It is therefore vital that these amino acids be replaced via ingestion.

Furthermore, because exercise augments the release of alanine and other nonessential amino acids, they would be available for protein synthesis following exercise. Therefore, if

additional amino acid supplementation were to have a positive effect on net muscle protein synthesis after exercise, in theory only essential amino acids would be necessary to elicit this effect.

ANALYSIS

The presence of a strong anabolic effect (positive nitrogen balance) from post-exercise amino acid consumption on muscle protein is strongly supported by several studies. Tipton et al. found that oral administration of amino acids after a resistance exercise routine resulted in significantly increased concentrations of the essential amino acids phenylalanine, leucine, and lysine in muscle tissue (4). A negative nitrogen balance was found after ingestion of a placebo solution containing no amino acids, whereas nitrogen balance became positive after ingestion of both a mixed amino acid (MAA) solution and an essential amino acid (EAA) solution. The study also found a similar anabolic response between EAAs and MAAs, indicating that EAAs alone are sufficient for initiating an anabolic response in muscle after exercise. However, the fact that the response was similar in both solutions when one solution contained 40 g EAA and the other contained 21 g EAA indicates that there is an underlying dose-response relationship between protein intake and increased muscle synthesis, and that both of these values may be above the threshold amino acid concentration needed for maximal synthetic increase. While the authors did not state a potential mechanism for the enhanced anabolic response from exogenous amino acids, they speculated that it might involve hormones, paracrine substances, or vasodilators. The study employed sound methodology and convincingly utilized previous studies to justify the conclusions reached.

In a later study, Levenhagen et al. compared the effect of different nutrient supplements on restoration of protein balance after exercise (5). The study examined three treatments: one with no nutrients (NO), one with a combination of carbohydrates and lipids without proteins (SUPP), and one with a combination of carbohydrates, lipids and proteins (SUPP+PRO). After a standardized resistance training program, net protein gain was observed in both the exercised muscle and the whole body from the SUPP+PRO treatment, while net protein loss was observed in both the NO and SUPP treatments. The study was well designed because it permitted examination of the independent effect of protein supplementation by holding carbohydrate and fat intake constant between the two treatments. The results also showed that the availability of amino acids is more important than the availability of energy for post-exercise muscle protein synthesis, primarily because there was no significant difference in synthesis between the NO and SUPP treatments. However, the study did not examine dose-response effects to determine what amount of protein stimulates maximal protein accretion, nor did it examine the effect of protein supplementation without carbohydrate or fat ingestion.

Esmarck et al. studied the effect of the timing of protein intake on muscle hypertrophy in elderly humans (6). The study found that over a 12 week resistance training period, muscle hypertrophy increased significantly when protein was ingested immediately after exercise, while no significant changes were observed when protein was supplemented 2 hours after exercise. These findings indicate that early consumption of protein after resistance training leads to higher net protein synthesis. However, the findings are specific to elderly men. Furthermore, the results seem to contradict the fact that protein synthesis has been shown to remain elevated for up to 2 day after resistance training (3).

Borsheim et al. analyzed this result in light of their study examining the effect of ingesting only essential amino acids (EAAs) on muscle protein synthesis after resistance training

(7). They found that ingestion of only 6 g of EAAs served as an effective stimulus for net muscle protein balance after resistance training, agreeing with the finding of Tipton et al. that ingestion of non-EAAs is not necessary to stimulate muscle protein synthesis (4,7). With respect to timing of intake, the study showed a similar protein synthesis response when EAAs were ingested 1 hour and 2 hours after exercise. This suggests that the timing of protein ingestion after exercise has little effect, which would agree with the finding of increased synthetic rate for 48 hours after resistance exercise. A comparison is complicated by the fact that protein was ingested in the Esmarck et al. study while free amino acids were ingested in this study. Although this might contribute to the difference in results, if post-exercise synthetic rate is indeed elevated above basal levels for the duration found by Chesley, amino acid intake should have roughly the same effect at any time during this elevated period.

The efficacy of whey protein as a protein supplement was examined by Burke et al. with respect to resistance training (8). The study demonstrated that males who received whey protein supplementation while undergoing resistance training showed a slight but significant (3.8%) increase in lean muscle mass compared to males who did the same training but received a placebo (comprised of maltodextrin). Importantly, the study acknowledged that the relatively small rather than large enhancement in lean muscle mass might be due to sufficient protein intake from the high protein diets of most strength-trained individuals. Methodologically, the study lacked effective monitoring of compliance because the subjects were not observed consuming their supplements.

There is at present relatively little data comparing the efficacy of whey protein as a supplement to other forms of protein supplementation. However, in a just recently published study, Brown et al. looked at soy bars and whey protein bars to determine whether there were differential effects on exercise-related increases in lean body mass as well as antioxidant status (9). According to the study, many male exercisers avoid soy protein because of a perception that it is inferior to whey protein for supporting increases in lean body mass. The study found that the subjects who took soy bars and those who took whey bars, combined with a defined resistance training program, both showed very similar and statistically significant increases in lean body mass compared to subjects who trained without supplements. However, the study also showed that soy protein subjects had better antioxidant capacities, as measured by two different parameters, compared to the whey group and the training-only group at the conclusion of the training period. Thus, whey protein may be as effective as other protein supplements in muscle gain but may be lacking in other benefits found in other forms of protein. This claim requires much more testing in the future, particularly because this study only had 9 subjects in each testing group, had only a 9 week training period, and had several variables that were not controlled, such as the diets of the subjects or their individual energy intake. Thus it is difficult to determine whether the effects observed were due specifically to the supplements or to other factors that were not controlled. Furthermore, one of the authors of the study owns the company that produces the soy bars used in the study, introducing a potential conflict of interest in the findings.

CONCLUSION

The presented scientific studies clearly indicate that the ingestion of amino acids through protein supplements augments muscle hypertrophy and retention of lean muscle mass, promoting positive nitrogen balance after resistance training. Whey protein has also been shown to provide these effects, although it may not contain the antioxidant benefits of other forms of protein.

However, it is important to note that all of these studies have demonstrated that post-exercise protein intake in any form is required to promote muscle anabolism. None advocate the use of a supplement over protein acquired from food. The protein requirement of individuals undergoing resistance training has been estimated to be 1-1.5 g/kg of body weight/day (1). This requirement is easily met in a normal balanced North American or European diet, particularly among athletes due to their increased consumption of food. Both the Tipton et al. and Burke et al. studies have indicated that increased consumption of protein beyond this requirement is unlikely to have an additional positive effect on muscle protein synthesis after resistance exercise. This is most likely because there is a maximal rate of protein synthesis, beyond which the ingestion of more amino acids will not have an effect. In fact, these extra amino acids would simply be excreted, and excess protein ingestion therefore has the capacity to place a significant strain on the kidneys due to the increased concentrations of nitrogen that must be removed from the body. Therefore, whey and other protein supplements should be taken only if protein intake from dietary sources is insufficient to meet the increased protein needs of resistance training.

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