The Role of Nutrient Timing in the Adaptive Response to Heavy Resistance Training

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Summary:

Consuming a combination of carbohydrate and protein during the pre-exercise, exercise, and post-exercise window will expedite recovery, improve performance, enhance various health parameters, and promote gains in lean body mass.

Previous studies have demonstrated that net amino acid uptake (an indicator of muscle protein synthesis) was greater when essential amino acids plus carbohydrates were ingested before resistance exercise rather than following exercise (1). Scientific evidence also suggests that combining carbohydrate with essential amino acids enhances muscle anabolism following resistance training to a greater extent than when either is consumed independently. Thus, the synergistic effect of carbohydrate and essential amino acid ingestion maximizes the anabolic response to resistance exercise. It is our view that this effect is due to an attenuation of the post-exercise rise in protein degradation (2). That said, it is unclear if this rule (i.e., pre is > post) applies to the ingestion of whole proteins. Recently, a group of scientists from the University of Texas Medical Branch in Galveston examined this very issue. In essence, they discovered that amino acid uptake was not significantly different between pre-workout and post-workout conditions. Thus, the response of net muscle protein balance to timing of intact protein ingestion does not respond in the same way as with the combination of free amino acids and carbohydrate (3). Or in plain English, whole proteins (e.g. milk, whey, meat, etc.) are probably not as effective as the essential amino acids when consumed pre-exercise. This is perhaps evidence to suggest that, in this case at least, supplements do indeed 'work better' than whole foods.

For individuals who choose to limit carbohydrate intake to maximize their ratio of lean mass to fat mass, the question of whether carbohydrate is needed as part of a nutrient timing strategy is indeed relevant. At least two studies have examined this question. The first study involved 14 weeks of resistance training combined with timed ingestion of isoenergetic (i.e. same calories) protein (25 grams) versus carbohydrate (25 grams) supplementation on muscle fiber hypertrophy and mechanical muscle performance. Subjects were instructed not to ingest anything else aside from plain water 2 hours before and 2 hours after the training session. On training days, the subjects consumed 25 grams of the protein or carbohydrate supplement immediately before training and immediately after the last set of the training session. On non-training days, subjects consumed one sachet (of the protein or carbohydrate supplement) mixed with water in the morning. Each sachet of protein powder contained 16.6 g of whey protein, 2.8 g of casein, 2.8 g of egg white protein, and 2.8 g of l-glutamine. Each sachet of carbohydrate powder contained 25 g of maltodextrin. After 14 weeks of resistance training, the protein group experienced an 18% and 26% increase in type I and type II muscle fiber cross-sectional areas, respectively; however, no change above baseline occurred in the carbohydrate group. Squat jump height increased only in the protein group, whereas countermovement jump height and peak torque during slow isokinetic muscle contraction increased similarly in both groups (4). Thus, the most important and critical finding in this study was that physically active individuals benefit (i.e. with greater muscle fiber size and enhanced squat jump performance) from timed protein supplementation in conjunction with heavy resistance training whereas carbohydrate supplementation had no effect.

The second study examined 10 weeks of resistance training and the ingestion of supplemental protein and amino acids on muscle performance and markers of muscle anabolism. Nineteen untrained males were randomly assigned to supplement groups containing either 20 g protein (14 g whey and casein protein, 6 g free amino acids) or 20 g dextrose placebo ingested 1 h before and after exercise for a total of 40 g/d. Participants exercised 4 times per week using 3 sets of 6 – 8 repetitions at 85 – 90% of the one repetition maximum. The investigators discovered that the protein supplement in comparison to the carbohydrate placebo resulted in greater increases in total body mass, fat-free mass, thigh mass, muscle strength, serum IGF-1, IGF-1 mRNA, MHC I and IIa expression, and myofibrillar protein. Thus, 10 weeks of resistance training with 20 g protein and amino acids ingested 1 h before and after exercise was more effective than carbohydrate placebo in up-regulating markers of muscle protein synthesis and anabolism along with subsequent improvements in muscle performance (5). Similarly, other investigations have shown that the ingestion of milk following resistance exercise results in phenylalanine and threonine uptake, representative of net muscle protein synthesis (6). Although two studies are far from concrete proof, they call into serious question whether carbohydrates are necessary (pre and post-exercise) to promote muscle fiber hypertrophy and resistance training adaptations.

In perhaps one of the more elegant studies in the literature, scientists examined the effects of supplement timing compared with supplementation in the hours not close to the workout on muscle-fiber hypertrophy, strength, and body composition during a 10 week resistance exercise (RE) program. In a single-blind, randomized protocol, resistance-trained males were matched for strength and placed into one of two groups; the PRE-POST (pre-workout and post-workout) group consumed a supplement (1 g x kg(-1) body weight) containing protein/creatine/glucose immediately before and after RE. The morning and evening (MOR-EVE) group consumed the same dose of the same supplement in the morning and late evening. All assessments were completed the week before and after 10 weeks of structured, supervised RE training. The results indicated that the PRE-POST treatment demonstrated a significantly greater increase in lean body mass and 1-RM strength in two of three exercises. The changes in body composition were supported by a significantly greater increase in size of the type II fibers (fast-twitch) and contractile protein content (7). This study confirms the notion that the timing of your nutrient intake does indeed greatly impact the adaptive response even when compared to the isocaloric and isonitrogenous consumption of the same nutrients.

While the aforementioned studies are interesting from an athletic perspective, what about general health and wellness? In an intriguing study, healthy male US Marine recruits from six platoons were randomly assigned to three treatments within each platoon. Nutrients supplemented immediately post-exercise during the 54-day basic training were either placebo (0 g carbohydrate, 0 g protein, 0 g fat), control (8, 0, 3), or protein supplement (8, 10, 3). Compared with placebo and control groups, the protein-supplemented group had an average of 33% fewer total medical visits, 28% fewer visits due to bacterial/viral infections, 37% fewer visits due to muscle/joint problems, and 83% fewer visits due to heat exhaustion. Recruits experiencing heat exhaustion had greater body mass, lean, fat, and water losses. Muscle soreness immediately post-exercise was reduced by protein supplementation vs. placebo and control groups on both days 34 and 54 (8). Though this investigation does not have direct application to athletic performance, it is worthwhile to note that consuming a 'meal' of 100 calories post-exercise can indeed confer a beneficial effect. Whether 100 calories consumed post-exercise can confer a benefit regarding body composition or exercise performance needs to be explored.

Take Home Message:

It is apparent from a growing body of literature that consuming protein (amino acids) or a combination of protein plus carbohydrate is important for enhancing the adaptive response to exercise (4, 9 – 16). Believe it or not, as little as 100 calories may be of benefit (8). Based on the existing literature, it is apparent that you can consume protein/amino acids pre- and post-exercise (without carbohydrate) and get significant benefits in terms of muscle fiber size and performance. The data, albeit limited, also suggest that essential amino acids plus carbohydrate is the best way to promote skeletal muscle protein accretion, particularly if consumed pre- and post-workout. Nevertheless, the data are quite robust regarding the benefits of consuming protein/amino acids, protein plus carbohydrate or essential amino acids plus carbohydrate post-exercise.

From a practical standpoint, it would make sense that athletes should be advised to consume some type of meal before and after training. For the sake of convenience, this meal may be best consumed as a ready-to-drink beverage. Strength-power athletes would likely need to place greater emphasis on protein (and less so on carbohydrate) because of the dietary needs related to skeletal muscle growth whereas endurance athletes may need proportionately more carbohydrate with protein to promote skeletal muscle glycogen repletion. Sports nutritionists must of course work with each individual to determine what works best for their particular athlete. Finally, regarding the safety of consuming protein, it should be noted that scientists recently concluded that "it appears that protein intake under 2.8 grams per kilogram of body weight does not impair renal function in well-trained athletes …" (17, 18) and they "find no significant evidence for a detrimental effect of high protein intakes on kidney function in healthy persons after centuries of a high protein Western diet" (19).

Thus, it would behoove all athletes to utilize a nutrient timing strategy so as to further enhance the adaptive response to exercise.

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