POST-WORKOUT NUTRITION—NUTRIENT TIMING AND THE ANABOLIC WINDOW

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The timing of nutrient ingestion surrounding an exercise bout has been the subject of much research and debate over the past few decades (1). While very few individuals would deny that pre- and post-workout nutrition is vitally important for the provision of substrates needed to fuel a workout, repair damaged tissues, and replenish energy stores following training, there is considerable debate surrounding the timing of ingesting nutrients and how to maximize the anabolic response to training, particularly when it comes to post-workout nutrition. This is commonly known as the "anabolic window."

The aim of the post-workout meal is to provide the body with the substrates needed to replenish body energy stores (e.g., carbohydrates to replenish skeletal muscle glycogen and fat to replenish triglyceride stores in skeletal muscle and adipose tissue), as well as repair damaged tissues (e.g., skeletal muscle). In addition, adequate fluids and electrolytes should also be consumed following an intense training session in order to restore hydration status and replace ions (e.g., sodium and potassium) lost through sweating. The timing and importance of these aspects of sports nutrition, however, are beyond the scope of this article.

While the importance of consuming a meal post-workout with adequate protein and carbohydrates is not under debate, the timing with which these nutrients are consumed is a highly debated subject. So much so that some even consider the timing of nutrients to be a greater factor with regards to muscle protein anabolism and recovery than overall nutrient ingestion alone (2). Unfortunately, the current state of the scientific literature does not support a clear conclusion in either direction. Therefore, the aim of this article is to summarize the relevant literature regarding post-workout nutrient timing and its importance towards training adaptations, specifically increasing skeletal muscle hypertrophy and replenishing skeletal muscle glycogen stores. Indeed, these two factors may be the most important factors affecting training muscular adaptations and performance.

SKELETAL MUSCLE HYPERTROPHY

Skeletal muscle hypertrophy, or simply an increase in skeletal muscle mass, is dependent upon the balance between muscle protein synthesis (MPS) and muscle protein breakdown (MPB), such that MPS is greater than MPB. Like protein, skeletal muscle is in a constant state of being produced and destroyed. For many individuals, increasing skeletal muscle mass is important for increased performance via increases in strength and power. Thus, increasing MPS and attenuating or preventing MPB following an intense training bout are of utmost importance. Without the proper ingestion of nutrients following training, a net decrease in skeletal muscle balance due to increases in MPB that outweigh MPS can occur (17). Without the inclusion of a post-workout meal, these increases in MPB can be seen even up to 24 hr after training and may lead to net decreases in muscle mass over time (12).

Inhibiting MPB and stimulating MPS can be achieved nutritionally through the ingestion of protein and carbohydrates, although an adequate amino acid or protein bolus alone may fulfill both nutrients' post-workout hypertrophic effects. In part, this process is nutritionally mediated through leucine (an amino acid found abundantly in proteins, especially whey), which stimulates an intracellular amino acid sensor called mammalian target of rapamycin (mTOR) (16). Through the activation of mTOR and its downstream effectors, the muscle cells increase the translation of proteins needed for skeletal muscle contraction, as well as numerous other proteins involved in the hypertrophic response (15). In addition, both protein and carbohydrates stimulate the production and release of insulin, which is needed for 1) the complete activation of mTOR and 2) the inhibition of MPB via insulin's signaling cascade involving protein kinase B and its activation and inactivation of various downstream targets involved in proteolysis (15,26). In the end, the proper ingestion of nutrients leads to increases in MPS, decreases in MPB, and an overall net accretion of lean tissue. The main question is whether or not the timing of these nutrients can beneficially effect the anabolic response and lead to greater increases in muscle mass?

To date, there are several relevant controlled studies that look at the effect of nutrient timing on long-term changes in skeletal muscle mass, specifically with regards to protein ingestion following a resistance training program lasting equal to or greater than 10 weeks in duration (3,4,5,8,9,23,24). However, significant limitations exist within and among these studies making any definitive conclusions about the "anabolic window" preliminary at best. In fact, a majority of these studies recruited relatively untrained individuals (typically older males) (4,5,9,24,23). Additionally, some of the studies did not match total protein intakes over the course of the study period (4,9,23,24). Moreover, all of the studies utilized different resistance training protocols and varied in body composition assessment methods. Thus, any firm conclusions about post-workout nutrient timing are based purely on opinion or experience rather than a cohesive body of rigorous scientific evidence.

There were three studies that matched protein intakes between the intervention (immediate) and control (delayed) groups rather than giving them non-protein placebos (3,5,8). Two of the three studies saw significant increases in muscle cross-sectional area using different measurement methods. One of these studies measured increases through magnetic resonance imaging (MRI) in the immediate versus delayed protein and carbohydrate groups (3). The other study measured the increases through dual-energy x-ray absorptiometry (DXA) in the immediate versus delayed protein and carbohydrate groups (5). The third study saw no differences between immediate and delayed nutrient ingestion (8).

The evidence to date, therefore, does not support a clear benefit of immediate versus delayed nutrient ingestion. However, in a recent meta-analysis looking at post-workout protein ingestion on strength and hypertrophy in over 500 subjects spanning 23 studies, Schoenfeld et al. showed that overall protein intake rather than timing was the primary determinant for predicting strength and hypertrophic outcomes (19). Nevertheless, this does not mean that post-workout nutrition is not important. The benefits of consuming the proper nutrients following a workout are well documented and should be regularly practiced (21).

REPLENISHING SKELETAL MUSCLE GLYCOGEN

Another aspect of post-workout nutrition is replenishing depleted fuel stores to provide energy for the next training bout. One of the most important fuel depots is glycogen because it fuels the majority of high-intensity skeletal muscle contraction, it can be rapidly exhausted depending on the intensity and duration of the training bout, and its relative storage capacity (approximately 1,200 kcals) is nothing close to that of adipose tissue (upwards of 100,000 kcals depending on leanness) (13,18). Therefore, the repletion of lost skeletal muscle glycogen stores can be seen as an important post-workout nutritional concern.

It has been shown that carbohydrate and protein administration immediately following training has profound effects on glycogen resynthesis rates, with a 50% reduction in glycogen resynthesis rates seen with a delayed ingestion of carbohydrates two hours after training (10,22). While the reality of expeditious nutrient ingestion with regards to glycogen resynthesis is not under contention, the utility of such dietary timing strategies apply only to a subset of athletes who compete in multiple glycogen depleting events throughout the day (e.g., swimmers, wrestlers, runners, cyclists, etc.). Thus, it can be argued that immediate post-workout protein and carbohydrate ingestion for the purposes of increased rates of glycogen synthesis may be of low importance for the majority of athletes who do not undergo twice-daily training sessions or who do not have multiple events over the course of 24 hr.

PRACTICAL NUTRITIONAL RECOMMENDATIONS

Multiple studies have shown a maximal anabolic response of skeletal muscle to protein ingestion maxing out around 25 – 40 g of high-quality protein that contains high levels of leucine (14,25). Thus, any more than this amount can be seen as unnecessary for skeletal muscle protein synthesis. For example, this could be accomplished by consuming a meal that includes 4 – 7 oz of lean meat, poultry, or fish, or 1 – 2 scoops of protein powder (e.g., whey, casein, or soy).

With regards to carbohydrates, there is a dearth of research related to long-term increases in skeletal muscle mass from carbohydrate consumption (6). Moreover, it has been shown that the inclusion of post-workout carbohydrates (e.g., 30 g of sucrose or 50 g of maltodextrin) alongside an adequate protein bolus (e.g., 20 – 25 g of whey protein) does not lead to any further increases in MPS compared to just protein alone (7,11,20). Thus, as long as carbohydrate-rich meals are consumed at some point during and after the post-workout period, and that adequate protein is consumed, glycogen stores should be replenished before the next training session and maximal synthetic rates of skeletal muscle protein can be achieved. It may be best to let personal preference, dietary goals, and carbohydrate tolerance dictate the source and overall amounts consumed.

CONCLUSION

In the end, no firm conclusions can be made about providing nutrients during the supposed post-workout "anabolic window." Rather, as long as adequate protein is consumed relatively shortly following training and daily macronutrient values are met, there is no reason to think that delaying a post-workout meal will have any measurable negative effects on skeletal muscle protein synthesis and increasing muscle mass.

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