Carbohydrates, Protein, and Recovery from Exercise

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How well a swimmer recovers from a workout can affect the quality of their next practice. Sprinters, in particular, rely heavily on muscle glycogen (stored carbohydrate) for energy during every performance, and there is a direct link between fatigue and muscle glycogen depletion. That is, quality workouts depend on replenishment of stores spent during previous sessions. Depending on the extent of depletion, it can take as long as 24 hours to fully replenish glycogen stores, but the first two hours post-workout are the most critical. Given the right fuel, glycogen synthesis during this time can occur as much as *2-3 times faster* than normal. This is due to the increased sensitivity of muscle cells to the hormone insulin.

It is well known that the ingestion of carbohydrate causes an insulin response (i.e. increasing glucose/sugar in blood increases insulin in the blood). The presence of insulin in the bloodstream promotes the uptake of glucose by the muscles. Once moved from blood to muscle, this glucose can then be converted to glycogen for storage. This conversion depends on stimulation from an enzyme called glycogen synthase, which is also sensitive to insulin. The general idea is to take advantage of the body's natural post-exercise sensitivity to insulin by providing it with food that will (1) raise insulin levels, (2) put glucose in the bloodstream quickly and (3) enhance the conversion of glucose to glycogen.

Certain proteins and amino acids have also been shown to elicit an insulin response and, when ingested with carbohydrate, create a "synergistic" effect. In other words, their combined effect is greater than the sum of their individual effects. Those found to have the greatest impact on insulin levels include protein hydrolysate mixtures, leucine, phenylalanine, and arginine. In addition, insulin itself has been proposed as an important factor in muscle protein balance by increasing synthesis and decreasing breakdown. Some believe that when exercise acts as the stimulus and levels of circulating amino acids are high, a more anabolic (muscle-building) state is created. Unfortunately, research in this area is still limited.

Several studies that examined the effects of various post-exercise carbohydrate/protein fuels on enhancing glycogen synthesis and protein metabolism after exercise. Their results helped answer some common questions about recovery from exercise:

How much is enough?

Consuming carbohydrate in the amount of 1.0-1.2 g/kg/hr (73-87 grams/hr for a 160 lb male) every hour for 4 hours is enough to maximize glycogen repletion following a tough workout.

What about added protein?

If a swimmer is consuming adequate amounts of carbohydrate (1.0 g/kg/hr, or 73 grams/hr for a 160 lb male) after an exhaustive dryland workout, adding protein or amino acid mixtures to the post-exercise fuel is not likely to enhance muscle glycogen replenishment. As far as its effect on protein synthesis, it doesn't seem to matter whether a recovery fuel is carbohydrate alone or carbohydrate combined with protein, as long as it provides at least 1.0 g CHO/kg/hr or fits the 1.0 g/kg/hr formula (4 kcal/kg/hr). Consuming

carbohydrate in the amount of 1.0 g/kg/hr for 4 hours appears to be as effective in replenishing glycogen stores as combining that same amount of carbohydrate with arginine. For highly trained athletes, it seems that the insulin response is more important to post-exercise protein synthesis than increasing the amount of circulating amino acids. The added insulin response caused by the addition of protein to a carbohydrate-only drink can be achieved just as effectively by adding the same amount of extra carbohydrate. With a post-exercise carbohydrate intake of 1.2 g/kg/hr or more, insulin loses its effect after two hours. After this point, the rate at which glycogen is made is more dependent on other factors, such as digestion and absorption rates.

Does gender make a difference?

The amount of recovery fuel needed after a tough workout depends on a swimmer's body weight, not their gender. Recognize that many male swimmers weigh more than female swimmers, but not always.

Why water is *not* enough.

Water alone will not replenish glycogen stores that have been spent during practice. A fuel containing 1.0 grams of carbohydrate per kg of body weight every hour is far superior. For the 160 lb swimmer, that equates to about 73 grams of carbohydrate every hour.

What else?

- Eating nothing at all will only allow muscle glycogen stores to remain low and reduces the potential for complete replenishment.
- It's ok to consume recovery fuel that contains a small amount of fat.
- To maintain an elevated insulin level, it may be beneficial to divide fuel intake into more frequent "doses," such as every 15-20 minutes versus every hour.

The Final Word

Recovering from one practice is just as important as fueling for the next. Changing workout intensity and/or duration can affect an athlete's nutritional needs during recovery. Keep these points in mind:

- Start the replenishment process **IMMEDIATELY**! The window for maximizing glycogen repletion starts to close as soon as exercise stops.
- Beyond the 1.0 g/kg/hr, it doesn't really matter whether it's extra protein or extra carbohydrate, as long as the caloric intake is sufficient (1.0 g or 4 kcal per kg per hour). For a 160 lb swimmer, that's at least 290 kcal/hr from carbohydrate, or that minimum plus some combination of carbohydrate and protein. Use the following table for reference:

Body Weight in lbs (kg)	Carbohydrate Required (g) to meet Intake of 1.2 g/kg	Amount of Common Commercially-Available 6% Carbohydrate Bottled Sports Drink	Food Examples (for every 30 minutes)

120 (54.5)	65 (33 g/30min)	37 oz/hr	1 cup apple juice
130 (59.1)	71 (36 g/30min)	41 oz/hr	1 serving low-fat yogurt
140 (63.6)	76 (38 g/30min)	44 oz/hr	½ cup dried apricots
150 (68.2)	82 (41 g/30min)	47 oz/hr	1 cup cranberry cocktail
160 (72.7)	87 (44 g/30min)	50 oz/hr	1/3 cup raisins
170 (77.3)	93 (47 g/30min)	53 oz/hr	2 cups grapefruit juice
180 (81.8)	98 (49 g/30min)	56 oz/hr	1 medium bagel
190 (86.4)	104 (52 g/30min)	60 oz/hr	2 slices watermelon
200 (90.9)	109 (55 g/30 min)	62 oz/hr	2 cups orange juice
210 (95.5)	115 (58 g/30min)	66 oz/hr	4 kiwi fruits
220 (100.0)	120 (60 g/30 min)	69 oz/hr	1 cup canned fruit salad

Reminder: The values in this table are presented as guidelines only. While replenishing in 30-minute intervals may be a little better in terms of keeping insulin levels elevated, a swimmer will still benefit from taking a "full dose" every hour instead.

- Adjust post-exercise fuel intakes accordingly. Encourage your swimmers to focus on maximizing glycogen repletion when practices are exhaustive, but they might not need to replenish as long when workouts are not as intense. Most replenishment periods should continue for at least two hours, but may last as long as five hours if the workout was completely exhaustive.

- Something is better than nothing. If the swimmer just can't meet the 1.0 g/kg/hr for at least two hours recommendation, consuming *some* carbohydrate fuel immediately after workout will do more to help prevent chronic or long-term glycogen depletion than consuming nothing at all.

- Save face and money. Extra protein does not appear to be any more beneficial to the recovery period than extra carbohydrate, so choosing a supplement over a conventional food item could cost an athlete more than he/she bargained for. For reference, one cup of apple juice provides 31 grams of carbohydrate, grapefruit juice-24 grams/cup, orange juice-27 grams/cup, cranberry cocktail-40 grams/cup, a slice of watermelon-26 grams, a single-serving container of low-fat yogurt-36 grams, canned fruit salad-61 grams/cup, and raisins-138 grams/cup.