Strategies for Post-Exercise Recovery

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Summary

Recovery after exercise is an essential element of the training-adaptation cycle. As a result, many professional and recreational athletes apply recovery strategies after their exercise sessions and/or competitive events. One frequently applied recovery strategy is nutrient intake, mainly carbohydrates and protein. Carbohydrates are an important fuel source used by our skeletal muscles allowing maximal performance during intense exercise. Our body is able to store only a limited amount of these carbohydrates in, mainly, our muscles and liver. Therefore, lots of carbohydrates are often ingested to quickly replenish carbohydrate (i.e. glycogen) stores in the muscles and liver during and/or after exercise. However, the absorption of carbohydrates in the intestine appears to be a rate-limiting factor. Therefore, it is relevant to investigate whether intestinal carbohydrate absorption can be improved. The monosaccharides glucose and fructose are absorbed via different pathways within our intestines, which means that the combined ingestion of glucose and fructose can further accelerate carbohydrate absorption rates when compared with the ingestion of only glucose or fructose. Given that table sugar (sucrose) contains both glucose and fructose in a 1:1 ratio, it may be an interesting carbohydrate source to ingest both during and after exhaustive exercise.

In **Chapter 2** we investigated whether the ingestion of sucrose during exercise is preferred to attenuate glycogen depletion in the liver and muscles when compared to the ingestion of only glucose or water. As expected, we observed a clear reduction in both liver and muscle glycogen concentrations when the athletes ingested only water during exercise. However, when the athletes ingested sucrose or glucose we observed that liver, but not muscle, glycogen concentrations were completely preserved during exercise. These results suggest that the ingestion of carbohydrate during exercise will spare liver, but not muscle, glycogen concentrations, independent of the source of carbohydrate.

In addition to the impact of sucrose intake during exercise, we investigated whether sucrose forms an effective strategy to accelerate the recovery of liver and muscle glycogen when ingested after exercise. In **Chapter 3** we describe a study where we investigated whether sucrose ingestion during recovery from exercise accelerates liver and muscle glycogen repletion when compared to glucose ingestion. Sucrose intake substantially accelerated liver, but not muscle, glycogen repletion compared to glucose intake. Therefore, it is concluded that the intake of sucrose will be more beneficial compared to glucose when glycogen stores in the liver need to be replenished rapidly during recovery from a bout of prolonged, exhaustive exercise.

In **Chapter 4** we provided an overview of what we currently know about the benefits of combining fructose and glucose ingestion during and after exercise. In this chapter we focus on explaining the benefits of fructose plus glucose ingestion for maximal performance during prolonged intense exercise as well as to accelerate post-exercise recovery.

As a second macronutrient of interest, protein and/or its constituent amino acids are frequently ingested after exercise in order to provide the body with building blocks for muscle recovery and growth. In particular, the branched-chain amino acids (BCAA's) are known to effectively stimulate muscle protein synthesis, which is an essential process for muscle recovery and growth. Within our muscles, BCAA's can be converted into their respective ketoacids (BCKA's) and these ketoacids can in turn also be converted back into BCAA's. There is still a lot unknown about the ingestion of these ketoacids and whether they can have a positive effect on muscle protein synthesis. In **Chapter 5**, we assessed the impact of BCAA and BCKA ingestion to stimulate muscle protein synthesis and compared this with the ingestion of a high-quality protein source (milk protein). We observed that BCAA, BCKA, and milk protein are all equally effective as a means to stimulate muscle protein synthesis during the first 2 hours after ingestion. However, after 2 hours only the ingestion of milk protein continued to stimulate this process. These findings suggest that consuming a high-quality protein source is a better option to stimulate muscle protein synthesis when compared to the ingestion of only the equivalent BCAA or BCKA.

Another high-quality protein source to ingest after exercise are eggs. Previous research has shown that when eggs are processed (i.e. cooked) prior to consumption, protein digestion and amino acid absorption will be faster and more effective. Consequently, more amino acids will become available in the circulation that can be used to stimulate muscle protein synthesis. In **Chapter 6** we investigated whether the consumption of boiled eggs will indeed lead to a stronger increase in muscle protein synthesis compared to the ingestion of raw, unboiled eggs. Despite amino acid availability being greater after ingesting boiled vs raw eggs, we did not find a difference in postprandial muscle protein synthesis rates during recovery from exercise.

Apart from nutritional strategies, athletes also apply other strategies to improve recovery after exercise. One of the frequently applied recovery methods after exercise is cold-water immersion. However, the impact of cold-water immersion on stimulating muscle protein synthesis remained unknown. In **Chapter 7** we showed that cold-water immersion after exercise lowers muscle temperature and attenuates the postprandial rise in muscle protein synthesis rates. In addition, we observed that muscle cooling lowers the capacity of the muscle to take up and incorporate amino acids coming from a milk protein drink into muscle protein. We can conclude that cold-water immersion does not always represent a good strategy to accelerate recovery after exercise and may actually compromise muscle conditioning during prolonged exercise training.

Given that a decline in muscle temperature attenuates the post-exercise increase in muscle protein synthesis rates, we subsequently investigated whether heating the leg muscles may increase muscle protein synthesis rates. In **Chapter 8** we investigated whether hot-water immersion during recovery from resistance exercise increases muscle protein synthesis rates. Heating skeletal muscle tissue did not further increase muscle protein synthesis rates during recovery from exercise and, as such, does not seem to be a proper strategy to improve muscle conditioning.

Besides nutritional strategies there are various other strategies that are being applied frequently by athletes with the aim to improve recovery after exercise. In the final

Chapter 9 we provided an overview of the known effects of different commonly applied post-exercise recovery strategies on accelerating glycogen repletion or stimulating muscle protein synthesis. With research on these topics being scarce, we specifically identify some interesting topics for future research in the area of post-exercise recovery and muscle conditioning.