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Protein Nutrition and Endurance Exercise: What Does Science Say?

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11/10/2006

Introduction

Athletes, coaches and scientists have recognized for decades that training and nutrition are highly interrelated when it comes to improving performance. An accumulating body of scientific evidence now confirms that nutrition can profoundly influence the molecular and cellular processes that occur in muscle during exercise and recovery.[1] This brief review analyzes the potential for performance enhancement through protein ingestion, whether during activity or by enhancing muscle recovery.

Protein Ingestion During Exercise

A properly formulated carbohydrate-electrolyte beverage (CEB) improves performance during exercise primarily because of two key ingredients: carbohydrate (CHO), which provides fuel for working muscles, and sodium, which helps to maintain fluid balance.[2] Recently, two studies suggested that adding a small amount of protein (~2% whey protein) to a CEB produced improvements in endurance capacity compared to the sports drink alone.[3,4] However, the practical relevance of these studies is hampered by the way the research was conducted. First, the rate of CHO delivered in the CEB was less than what is considered optimal for performance[2]; and second, the method of the performance test (exercise time to fatigue) did not mimic the manner in which athletes typically compete. In a recent study[5], we addressed these issues by having trained cyclists ingest a CEB during exercise at a rate considered optimal for CHO delivery (60 gram per hour), and perform a task that closely simulated athletic competition.

Subjects performed an 80-km cycling time trial on three occasions and drank either a 6% CHO blend, a 6% CHO + 2% whey-protein blend, or a sweetened placebo. All of the subjects consumed the solutions at a rate of 1 liter per hour. The study was “double blind” meaning neither the athletes nor the researchers knew what drink was consumed during a given trial. The study was also counterbalanced so that the order in which the subjects received the three treatments was systematically varied to prevent test-order bias. The trials determined that the average performance time was identical during the CHO and CHO+protein trials (roughly 135 min) and both were significantly faster (by approximately 4%) than the placebo trial (141 min). This study[5] demonstrated that when athletes ingested a CEB during exercise at a rate considered optimal for CHO delivery, protein provided no additional performance benefit during an event that simulated “real life” competition.

Amino Acid Supplementation During Exercise

In addition to whole proteins, many studies have examined whether consuming specific amino acids or amino-acid mixtures improves exercise performance. These studies have generally reported no benefit, although the issue of branched-chain amino acid (BCAA) supplementation remains debateable.[6] In this author’s opinion, the most well-controlled studies show no effect of BCAA supplementation on performance.[7] This view is supported by two recent studies[8,9] that investigated the effect of this practice during exercise in the heat. The studies involved manipulations designed to reduce glycogen availability and induce dehydration. This technique was used in order to simulate the metabolic conditions athletes experience during the latter stages of prolonged exercise. Using a time trial and exercise to voluntary exhaustion[9], both studies found no effect of BCAA ingestion on performance.

Protein Ingestion During Recovery and Acute Muscle Adaptations

Nutrition intake during the immediate post-exercise period may benefit the athlete in that it aids the synthesis of muscle proteins and the replenishment of muscle glycogen. Similar to the effect seen after resistance exercise[10], consuming protein with CHO during recovery from endurance exercise promotes muscle repair.[11] This effect may be due to a direct effect of amino acids (particularly BCAA) on signaling pathways that control muscle protein synthesis.[12] A more controversial issue is whether consuming protein with CHO enhances muscle glycogen resynthesis during the first several hours of recovery from prolonged exercise. In this author's opinion, which is consistent with leading researchers in the field[13], most evidence suggests that ingesting a high amount of CHO at frequent intervals (e.g., ≥ 1.2 g CHO per kg body weight per hour) negates the benefits of added protein. However, if an athlete does not eat a sufficient amount of CHO during recovery, then consuming protein with CHO may augment glycogen synthesis. Thus, similar to the effect on endurance capacity, the beneficial effect of ingesting protein with CHO on glycogen storage may be due to higher energy (nutrient) intake *per se* rather than any unique physiological mechanism.

Protein Ingestion During Recovery and Subsequent Exercise Performance

Regardless of the potential changes in muscle, one key issue for some athletes is whether consuming protein with CHO during recovery improves subsequent endurance performance. One study[14] reported that ingesting a CHO-protein drink during recovery from glycogen depleting exercise (activity lasting more than 90 minutes) markedly improved time to exhaustion during a subsequent exercise bout, as compared to a sports drink. However, the CHO-protein drink provided approximately three times as many calories as the sports drink and thus the improved endurance capacity was likely due to the higher energy intake. Another study[15] that did not match energy intake compared chocolate milk, a dilute CHO sports drink and a drink matched to chocolate milk in terms of protein and CHO content. Endurance capacity was improved with chocolate milk and the sports drink compared to the third beverage, even though the latter provided CHO and protein equivalent to chocolate milk and more CHO and energy than the sports drink. The mechanisms that might explain the rather surprising findings from this study remain to be elucidated.

Studies that have compared a CHO-protein drink with a CHO drink that provided the same amount of energy, showed no difference in subsequent 5-km running time trial[16] or a timed run to exhaustion[17]. Additional research in this area is warranted, but at present there is no compelling evidence that suggests consuming protein with CHO during recovery has a direct effect on subsequent exercise performance. Nonetheless, given that protein has been shown to promote muscle recovery after strenuous exercise[11], it seems prudent for athletes to consume protein with CHO as part of their recovery nutrition strategy.

Conclusions

- Some studies have suggested that consuming protein with CHO during exercise improves endurance performance while other studies have reported no benefits. Additional research will resolve this debate, but it should be remembered that there is no established mechanism by which protein intake during exercise should improve performance.
- Recent evidence indicates that when CHO is consumed in sufficient amounts during exercise, adding protein provides no performance benefit and does not enhance muscle glycogen synthesis following exercise.
- Consuming a small amount (10-20 grams) of high-quality protein after exercise promotes muscle protein synthesis compared to CHO alone and may enhance the body's response to long-term training.

References

1. Hawley, J.A., Tipton, K.D., and Millard-Stafford, M.L. Promoting training adaptations through nutritional manipulations. *J Sports Sci*. 24:1-13, 2006.

2. Jeukendrup, A.E. Carbohydrate intake during exercise and performance. *Nutrition* 20:669-677, 2004.

3. Ivy, J.L., Res PT, Sprague, R.C., and Widzer, M.O. Effect of a carbohydrate-protein supplement on endurance performance during exercise of varying intensity. *Int. J. Sports Nutr. Exerc Metab.* 13:382-395, 2003.

4. Saunders, M.J., Kane, M.D., and Todd, K.M. Effects of a carbohydrate-protein beverage on cycling endurance and muscle damage. *Med. Sci. Sports Exerc.* 36:1233-1238, 2004.

5. van Essen MJ, and Gibala MJ. Failure of protein to improve time trial performance when added to a sports drink. *Med Sci Sports Exerc*. 38:1476-1483, 2006 (In press).

6. Gleeson, M. Interrelationship between physical activity and branched-chain amino acids. *J Nutr*. 135:1591S-1595S, 2005.

7. van Hall G, Raaymakers, J.S., Saris, W.H., Wagenmakers, A.J. Ingestion of branched-chain amino acids and tryptophan during sustained exercise in man: failure to affect performance. *J Physiol*. 486: 789-794, 1995.

8. Cheuvront, S.N., et. al. Branched-chain amino acid supplementation and human performance when hypohydrated in the heat. *J Appl Physiol*. 2004 97:1275-1282, 2004

9. Watson, P., Shirreffs, S.M., Maughan, R.J. The effect of acute branched-chain amino acid supplementation on prolonged exercise capacity in a warm environment. *Eur J Appl Physiol*. 93:306-314, 2004.

10. Rennie, M.J., et. al. Control of the size of the human muscle mass. *Annu Rev Physiol*. 66:799-828, 2004.

11. Levenhagen, D.K., et. al. Postexercise protein intake enhances whole-body and leg protein accretion in humans. *Med Sci Sports Exerc*. 24:828-837, 2002.

12. Blomstrand, E., Eliasson, J., Karlsson, H.K., Kohnke, R. Branched-chain amino acids activate key enzymes in protein synthesis after physical exercise. *J Nutr*. 136: 269S-273S, 2006.

13. Burke, L.M., Keins, B., and Ivy, J.L. Carbohydrates and fat for training and recovery. *J. Sports Sci*. 22:15-30, 2004.

14. Williams, M.B., Raven, P.B., Fogt, D.L., Ivy, J.L. Effects of recovery beverages on glycogen restoration and endurance exercise performance. *J Strength Cond Res*.17: 12-19, 2003.

15. Karp, J.R. et. al. Chocolate milk as a post-exercise recovery aid. *Int J Sports Nutr Exerc Metab.* 16:78-91, 2006.

16. Millard-Stafford, M., Warren, G.L., Thomas, L.M., Doyle, J.A., Snow, T., Hitchcock, K. Recovery from run training: efficacy of a carbohydrate-protein beverage? *Int J Sport Nutr Exerc Metab*. 15:610-624, 2005.

17. Betts, J.A., et. al. Recovery of endurance running capacity: effect of carbohydrate-protein mixtures. *Int J Sport Nutr Exerc Metab*. 15:590-609, 2005.