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Review article

PROTEIN HYDROLYSATES IN SPORTS AND EXERCISE: A BRIEF REVIEW

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ABSTRACT
Protein can be hydrolyzed, producing small chains of amino acids called peptides. Several studies have shown that protein hydrolysates containing mostly di- and tripeptides are absorbed more rapidly than free form amino acids and much more rapidly than intact proteins. In addition, there is recent evidence that protein hydrolysate ingestion has strong insulinotropic effect. Thus, recovery sports drinks containing protein hydrolysates may be of great value.

KEY WORDS: Proteins, amino acids, protein hydrolysates, ergogenic aids, sports supplements

INTRODUCTION

Today, we have four ways to get amino acids into the bloodstream: *1)* whole food proteins: *2)* intact protein supplements, *3)* free form amino acids, and *4)* protein hydrolysates (Manninen, 2002). Protein can be hydrolyzed, producing small chains of amino acids called peptides. This process mimics our own digestive actions thus making it an ideal way to process protein.

Protein hydrolysates are produced from purified protein sources by heating with acid or preferably, addition of proteolytic enzymes, followed by purification procedures (Bucci and Unlu, 2000). Enzyme hydrolysis is greatly preferred because acid hydrolysis oxidizes cysteine and methionine, destroys some serine and threonine, and converts glutamine and asparagine to glutamate and aspartate, respectively, lowering protein quality and biological value (Bucci and Unlu, 2000).

Several studies have shown that protein hydrolysates containing mostly di- and tripeptides are absorbed more rapidly than free form amino acids and much more rapidly than intact proteins (Di Pasquale, 1997). The considerably greater absorption rate of amino acids from the dipeptide than from the amino acid mixture appears to be the result of uptake by a system that has a greater transport capacity than amino acid carrier system, thus minimizing competition among its substrates (Di Pasquale, 1997). This is a desirable trait for athletes who wish to maximize amino acid delivery to muscle.

However, whether this apparent advantage over ingestion of foodstuffs has a practical effect of faster muscle mass accretion or improved recovery from exercise has not been adequately studied in exercising individuals. Nevertheless, documented advantages (faster uptake of amino acids, higher biological value) remain attractive to consumers. In addition, there is recent evidence that protein hydrolysate ingestion has strong insulinotropic effect. Thus, this article examines some science behind protein hydrolysates applied to sports and exercise.

Principal actions of insulin related to sports and exercise

Insulin is peptide hormone produced by the beta cells of the pancreas. Physiological effects of insulin are far-reaching and complex. They are conveniently divided into rapid, intermediate, and delayed actions, as listed in Table 1. The best know is the hypoglycemic effect, but there are additional effects on amino acid and electrolyte transport, many enzymes, and growth. The net effect of the hormone is storage of carbohydrate, protein, and fat.

Table 1. Principal actions of insulin. Data from Ganong (2001).

Rapid (seconds)
Increased transport of glucose, amino acids, and K^+ into insulin-sensitive cells
Intermediate (minutes)
Stimulation of protein synthesis
Inhibition of protein degradation
Activation of glycolytic enzymes and glycogen synthase
Delayed (hours)
Increase in mRNAs for lipogenic and other enzymes

From our understanding of insulin physiology we can see different ways in which insulin might be a performance-enhancing agent:

1. Through facilitating glucose entry into cells in amounts greater than needed for cellular respiration it will stimulate glycogen formation. Thus, insulin will both increase muscle glycogen concentrations prior to exercise and in the recovery phase after exercise.
2. Insulin is also being used in more haphazard way, particularly to increase muscle mass in bodybuilders. It has been long known that insulin-treated patients with diabetes have an increase in lean body mass when compared with matched controls (Sonksen 2001).

Effects of protein and amino acids on insulin secretion

Formerly, it was believed that insulin secretion was controlled almost entirely by the blood glucose concentration. However, as more has been learned about the metabolic functions of insulin for protein and lipid metabolism, it has become apparent that blood amino acids and other factors also play important roles in controlling insulin secretion.

Protein meals, infusion of physiological amino acid mixtures, or certain individual amino acids cause insulin release in humans even under conditions where the blood sugar changes little from its basal level (Newgard and Matschinksy 2001). However, changes of blood sugar levels markedly influence the responsiveness of beta cells to individual amino acids. For example, hypoglycemia reduces insulin release to amino acid mixtures and most individual amino acids (Newgard and Matschinksy 2001). Studies on isolated perfused rat pancreas and islets have demonstrated that physiological amino acid mixtures and even pharmacological concentrations of individual amino acids require the presence of permissive levels of glucose to be effective beta cell stimulants. However, leucine is an exception (Newgard and Matschinksy, 2001).

In a recent well-controlled study by van Loon et al. (2000a), a total of 10 drinks were tested in 8 nonobese males after an overnight fast to investigate the insulinotropic potential of several free amino acids, protein hydrolysates, and an intact protein. At 0, 30, 60, and 90 min, the subjects received a beverage 3.5 $mL \cdot kg^{-1}$ to ensure a given dose of 0.8 g $carbohydrate \cdot kg^{-1}$ (50% as glucose and 50% as maltodextrin) and 0.4 $g \cdot kg^{-1}$ of an amino acid and protein hydrolysate mixture every hour. The results of this study indicate that oral ingestion of some amino acid mixtures in combination with carbohydrates can produce strong insulinotropic effects.

To compare the insulinotropic effect of the ingestion of the protein hydrolysates with that of an intact protein, sodium-caseinate was provided in one of the drinks. This resulted in an insulin response that was not significantly different from that found with the control trial (30% greater) and tended to be less than the responses observed after ingestion of the protein hydrolysates. After ingestion of the intact protein, plasma amino acid responses over this 2-h period were in general lower than the responses observed after ingestion of the protein hydrolysates.

Regression analysis of the insulin responses and the changes in the plasma amino acids concentrations over the 2-h period showed a strong positive correlation between the observed insulin response and changes in plasma leucine ($p < 0.003$), phenylalanine ($p < 0.0001$), and tyrosine ($p < 0.0001$) concentrations. As pointed out by authors, this agrees with several *in vivo* studies in which β-cells of pancreas were incubated with leucine and phenyalanine and with the *in vivo* studies by Floyd et al. in which amino acids were infused (for references see van Loon et al., 2000a). The correlation observed with tyrosine concentrations may be explained by the fact that tyrosine is formed by the hydroxylation of phenylalanine when large amounts of phenyalanine are ingested. Interestingly, the addition of free glutamine hardly influenced plasma glutamine levels. Also, the data in this study show clearly that oral ingestion of large amounts of free arginine is not an effective means of increasing plasma insulin concentrations and plasma arginine concentrations.

The main conclusion is that oral intake of protein hydrolysates and amino acids in combination with carbohydrates can result in an insulinotropic effect as much as 100% greater than with the intake of carbohydrates only.

In another excellent study by van Loon et al. (2000b), after an overnight fast, eight male cyclists visited at laboratory on five occasions, during which a control and two different beverage compositions in two different doses were tested. After they performed a glycogen-depletion protocol, subjects received a beverage (3.5 $mL \cdot kg^{-1}$) every 30 min ensure an intake of 1.2 $g \cdot kg^{-1} \cdot h^{-1}$ carbohydrate and 0, 0.2 or 0.4 $g \cdot kg^{-1} \cdot h^{-1}$ protein hydrolysate and amino acid mixture.

After the insulin response was expressed as the area under curve, only the ingestion of the beverages containing protein hydrolysate, leucine and phenylalanine resulted in a marked increase in insulin response compared with carbohydrate-only trial. Further, a dose-related effect existed because doubling the dose (0.2-0.4 $g \cdot kg^{-1} \cdot h^{-1}$) led to an additional rise in insulin response ($p < 0.05$). Plasma leucine, phenylalanine and tyrosine concentrations showed strong correlations with the insulin response ($p < 0.0001$).

In addition, plasma amino acid concentrations were generally lower after the ingestion of drinks contraining protein hydrolysate + phenylalanine + leucine compared to with the control drinks, although in the latter, considerable amount of protein and amino acids were ingested. As pointed out by authors, this seems to suggest that tissue amino acid uptake and possibly also post-exercise net muscle protein balance were increased after the ingestion of this insulintropic mixture.

This would be in line with several studies demonstrating that an increase in plasma insulin concentration, during conditions of hyperaminoacidemia, further increases net muscle protein balance in vivo in humans (for references, see van Loon et al., 2000a.). Such a stimulating effect on net protein balance may in part also be a consequence of a stimulating effect of leucine on skeletal muscle protein synthesis, independent of an increase in insulin levels (Anthony et al., 2000). According to authors, this study provided a practical tool to markedly elevate insulin levels and plasma amino acid availability through dietary manipulation, which may be of great value in recovery sports drinks.

More recently, Calbet and MacLean (2002) reported that the combined administration of glucose and protein hydrolysates stimulates a synergistic release of insulin, regardless of the protein source. They concluded that peptide hydrolysates are absorbed at a faster rate from the small intestine than are whole milk proteins delivered as a milk solution, as reflected by the rapid increase in the plasma concentration of branched-chain amino acids in peripheral blood.

Further, the whey peptide hydrolysate elicited the greatest availability of amino acids during the 3-h postprandial period. According to Calbet and MacLean (2002), the association of high levels of plasma amino acids and insulin might explain a superiority of peptide hydrolysates over whole proteins in promoting better nitrogen utilization, especially when administered in combination with glucose.

CONCLUSION

Recovery sports drinks containing protein hydrolysates and insulinotropic amino acids may be of great value. However, the potential to stimulate post-exercise net muscle protein anabolism, and the mechanisms involved, remains to be investigated.

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KEY POINTS

- Protein hydrolysates containing mostly di- and tripeptides are absorbed more rapidly than free form amino acids and much more rapidly than intact proteins.
- Oral intake of protein hydrolysates and amino acids in combination with carbohydrates can result in an insulinotropic effect as much as 100% greater than with the intake of carbohydrates only.
- Recovery sports drinks containing protein hydrolysates and insulinotropic amino acids may be of great value, but more research is needed before firm conclusions can be drawn.

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