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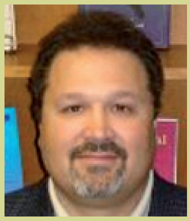
Dietary proteins
for muscle recovery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ABSTRACT: High-intensity and prolonged exercise creates the potential for a catabolic state resulting in protein degradation. The repair of muscle tissue following intense exercise is critical in promoting recovery and optimizing training adaptations. Individuals engaged in intense exercise training have greater protein needs. Additionally, research shows that timing dietary protein and/or amino acid ingestion can play an important role in promoting protein synthesis and recovery from exercise. The purpose of this perspectives article is to overview the role of dietary protein in optimizing recovery from exercise, and how ingestion of protein and/or amino acids prior to and following exercise can optimize protein synthesis and recovery.

INTRODUCTION

Finding an effective nutritional regimen for optimal recovery is fundamental to enhancing exercise training and performance (1, 2). There has been a considerable amount of research focusing on identifying nutri¬tional strategies to optimize recovery. Undoubtedly, restoring muscle glycogen is paramount to optimal recovery, particularly in individuals engaged in heavy training multiple days/week, and particularly for those who train more than once/day. However, recent research has been directed toward the examination of protein as an important co-factor in optimizing recovery and stimulating muscle protein synthesis. Nutritional strategies employed have included increased meal frequency (3), and timed nutrient intake prior to, during, and/or following exercise to maximize stimulatory effects during the recovery period (4, 5). It is now well-established that individuals engaged in intense training have greater protein needs, which have been attributed to increased intramuscular protein oxidation, as well as protein breakdown during exercise (2, 4, 5). Nutrient timing has been shown to play a critical role in optimizing protein synthesis and adaptations to exercise (4). A strategic nutritional approach to recovery, encompassing the metabolic timeframe of nutritional opportunity, is of paramount importance in the pursuit of optimal nitrogen balance, performance and recovery. These strategies may not only benefit individuals engaged in high-intensity or prolonged exercise training, but also individuals initiating training, attempting to lose weight without loss of lean tissue, and the elderly as a countermeasure against sarcopenia (6). The purpose of this article is to overview the role of dietary protein in optimizing recovery from exercise, protein synthesis, and training adaptations.

ROLE OF DIETARY PROTEIN

Protein is an essential nutrient that is integrated into every cell and tissue of the body. Dietary protein is necessary for growth and repair of tissue as well as many metabolic and hormonal processes (5). Some functions of protein include serving as transport proteins, hormones, enzymes, and neurotransmitters. In addition, protein can serve as an oxidative energy source when carbohydrate availability is low. Dietary proteins are degraded through digestion into amino acids. There are 22 amino acids (AA) which may be used to construct proteins (Table 1). Of these, eight are considered essential amino acids (EAA) in adults (nine in children) because the body can't synthesize these amino acids, and are therefore dependent on obtaining them from dietary protein. Another seven amino acids are considered conditionally essential amino acids because, although the body has the ability to synthesize them, the process is not adequate to meet daily needs without sufficient quantities of these amino acids in the diet. The remaining seven amino acids are considered non-essential amino acids because they can easily be synthesized if dietary sources are lacking.

Essential Amino Acids	
Isoleucine	Phenylalanine
Leucine	Threonine
Lysine	Tryptophan
Methionine	Valine
Nonessential	
Alanine	Glutamic Acid
Asparagine	Glycine
Aspartic Acid	Serine
Citruline	
Conditionally Essential	
Arginine[a]	Proline
Cysteine[b]	Taurine
Glutamine	Tyrosine[c]
Histidine[d]	

[a]Children have reduced capacity to produce arginine
[b]Cysteine (cysteine) is produced from methionine
[c]Tyrosine is produced from phenyalanine
[d]Infants cannot produce histidine

Table 1. Essential, nonessential and conditionally essential amino acids.

Dietary proteins that contain all of the EAA are considered complete proteins, whereas proteins that do not are considered incomplete proteins. Dietary protein quality is rated in part based on the amount of essential amino acids contained in them. For example, proteins that have low protein digestibility corrected amino acid scores (PDCAAS) or protein efficiency ratios (PER) are considered poor quality proteins (e.g., gelatin, wheat) while those with higher values (e.g., beef, soy, egg, milk, casein, colostrum, and whey protein) are considered high quality protein sources (Table 2). Generally, animal sources of protein are complete sources of protein whereas plant sources are incomplete proteins. Soy protein which is deficient of methionine is nevertheless considered a high quality protein because it has a concentration of essential amino acids. Differences among types of protein influence availability of amino acids and peptides that have been reported to possess biological activity (e.g., α-lactalbumin, ß-lactoglobulin, glycomacropeptides, immunoglobulins, lactoperoxidases, lactoferrin, etc.) (2, 6). Additionally, the rate of digestion and/or absorption and metabolic activity of the protein also are important considerations. For example, different types of proteins (e.g., casein and whey) digest at different rates, which directly affect whole body catabolism and anabolism (7, 8). Therefore, active individuals need to exercise care in identifying which types of protein they consume in order to maximize the physiological effects.

Protein	PDCAAS	PER
Gelatin (Collagen)	0.08	-
Wheat	0.43	1.5
Beef/Poultry/ Fish	0.8–0.92	2.0–2.3
Soy	1.00	1.8–2.3
Ovalbumin (Egg)	1.00	2.8
Milk Protein	1.00	2.8
Casein	1.00	2.9
Bovine Colostrum	1.00	3.0
Whey	1.00	3.0–3.2

Table 2. Protein digestibility corrected amino acid scores (PDCAAS) and Protein efficiency ratios (PER) for common types of protein sources.

DIETARY PROTEIN NEEDS

It is well accepted that adequate protein intake is crucial in maintaining cellular integrity, function, and health by contributing amino acids that serve as precursors for essential molecules which in turn serve as building blocks for all cell components (5, 6). Table 3 shows general recommendations for protein intake based on age and gender. The recommended daily allowance (RDA) for protein in healthy adults is 0.8 g/kg/day (5, 6, 9). This recommended protein intake is estimated to sufficiently meet the needs of nearly all (97.5 percent) healthy men and women aged 19 years and older, and account for individual differences in protein metabolism, variations in the biological value of protein, and nitrogen losses in human waste. This amount of protein intake may be appropriate for non-exercising individuals, but is not sufficient to meet the protein needs of individuals engaged in heavy work or exercise. Factors such as protein quality, energy intake, carbohydrate intake, mode and intensity of exercise, and the timing of the protein intake should be considered when determining an optimal amount of dietary protein for exercising individuals (5, 6).

Age (years)	Recommended Amount (g/kg/day)	
	Males	Females
11–14	1.0	1.0
15–18	0.9	0.8
19+	0.8	0.8

Table 3. Recommended intake of protein.

PROTEIN NEEDS FOR ACTIVE INDIVIDUALS

Protein can contribute as much as 5-10 percent of oxidative energy needs during prolonged exercise, particularly when carbohydrate stores are depleted. Research also shows that additional dietary protein is necessary to promote repair of exercise-induced tissue damage and promote lean tissue accretion (5, 6). For this reason, there has been interest in determining whether individuals engaged in heavy work or training might have greater protein needs. Although this issue was debatable 20-30 years ago, more recent evidence clearly indicates that athletes have greater protein needs depending on the volume of training in which they are engaged (2, 5, 6). The International Society of Sports Nutrition (ISSN) recently evaluated the available literature and published a position stand related to protein intake for athletes (5). Additional information can be found by reviewing this position stand. Nevertheless, the major conclusions from the ISSN position stand were:

1. Exercising individuals need approximately 1.4 to 2.0 grams of protein per kilogram of bodyweight per day.
2. Concerns that protein intake within this range is unhealthy are unfounded in healthy, exercising individuals.
3. An attempt should be made to obtain protein requirements from whole foods, but supplemental protein is a safe and convenient method of ingesting high quality dietary protein.
4. The timing of protein intake in the time period encompassing the exercise session has several benefits including improved recovery and greater gains in fat free mass.
5. Protein residues such as branched chain amino acids have been shown to be beneficial for the exercising individual, including increasing the rates of protein synthesis, decreasing the rate of protein degradation, and possibly aiding in recovery from exercise.
6. Exercising individuals need more dietary protein than their sedentary counterparts.

Table 4 provides a guide for protein intake based on the amount of exercise training in which individuals are involved. Basically, individuals involved in general fitness training (e.g., 30 minutes/day on most days per week) can meet protein needs by ingesting 1.0 – 1.4 g/kg/day of quality protein per day. Those engaged in moderate intensity and volume training (e.g., 30-60 minutes/day on most days of the week) should ingest 1.4 – 1.7 g/kg/day. Athletes engaged in high intensity and volume training (e.g., 60–120 minutes/day, 5–6 days per week) should ingest 1.7–2.0 g/kg/day. Additionally, athletes who are training 1-2 hours/day at altitude should consume 2.2 g/kg/day in order to meet protein needs.

Training Level	Recommended Amount (g/kg/day)
General Fitness	1.0–1.4
Moderate Intensity and Volume	1.4–1.7
High Intensity and Volume	1.7–2.0
High Volume Training at Altitude	2.0–2.2

Table 4. Recommended protein intake for active individuals.

NUTRIENT TIMING

Research has shown that strategically timing nutrient intake prior to, during, and/or following exercise can optimize performance and recovery. For example, research has shown that ingesting as little as 6, and up to 12 grams of free form EAA's, or intact protein sources prior to, during, and/or following exercise can have positive effects on protein synthesis and markers of skeletal muscle protein balance (10-15). These results have been attributed to the attenuation of protein breakdown, perhaps more so to the up-regulation of protein synthesis, and perhaps a balance of both. The ISSN also recently published a position stand (4) related to nutrient timing.

The ISSN concluded the following:

1. Prolonged exercise (> 60–90 min) of moderate to high intensity exercise will deplete the internal stores of energy, and prudent timing of nutrient delivery can help offset these changes.
2. During intense exercise, regular consumption (10–15 fl oz.) of a carbohydrate/electrolyte solution delivering 6–8 grams of carbohydrate/100 ml fluid (6-8 percent solution) should be consumed every 15–20 minutes to sustain blood glucose levels.
3. Glucose, fructose, sucrose and other high-glycemic carbohydrate sources are easily digested, but fructose consumption should be minimized as it is absorbed at a slower rate and increases the likelihood of gastrointestinal problems.
4. Ingestion of protein (0.15–0.25 g/kg) with carbohydrate, especially after exercise, is well tolerated and may promote greater restoration of muscle glycogen when carbohydrate intakes are suboptimal.
5. Ingestion of 6 grams of EAA or 20 grams of whey protein with or without carbohydrate within three hours after an exercise bout and immediately before exercise has been shown to significantly stimulate muscle protein synthesis.
6. Daily post-exercise ingestion of a carbohydrate and protein supplement promotes greater increases in strength and improvements in lean tissue and body fat percentage during regular resistance training.
7. Milk protein sources (e.g., whey and casein) exhibit different kinetic digestion patterns and may subsequently differ in their support of training adaptations.
8. Addition of creatine monohydrate to a carbohydrate and protein supplement in conjunction with regular resistance training facilitates greater improvements in strength and body composition as compared to when no creatine is consumed.
9. Dietary focus should centre on adequate availability and delivery of carbohydrate and protein. However, including small amounts of fat does not appear to be harmful, and may help to control glycemic responses during exercise.
10. Irrespective of timing, regular ingestion of snacks or meals providing both carbohydrate and protein (3:1 ratio) helps to promote recovery and replenishment of muscle glycogen when lesser amounts of carbohydrate are consumed.

SUMMARY

Individuals engaged in intense training, whether strength, power, or endurance have greater dietary protein needs. Additionally, strategic timing of the right types and amounts of EAA and/or protein can affect protein synthesis, recovery, and training adaptations. Therefore care should be taken when selecting which dietary protein sources should be ingested throughout the day. Although most active individuals can obtain sufficient amounts of protein in their diet, dietary protein supplements provide a convenient way to ensure that daily protein needs are met, and that nutrient ingestion is properly timed prior to, during, and/or following exercise to optimize recovery and training adaptations.

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