Protein Supplementation and Athlete Performance

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Protein Basics

- Proteins are composed of amino acids (AA), some of which must be obtained through the diet (essential), and others which can be formed from other substrates (non-essential).

- 4 kcals per gram
- Contains Nitrogen (Amino = nitrogen containing)
- Most body proteins are polypeptides that contain > 100 amino acids linked together
Protein

One of 20 unique amino acids

Amino group - NH$_2$

Carboxylic acid group - COOH

Generic Amino Acid

Alanine
Food Sources of Protein

• Food protein is only considered “complete” if it contains all of the essential amino acids.
  • Examples: milk, eggs, meat, poultry, and fish.

• Food proteins that lack one or more of the essential amino acids are termed “incomplete” and not capable of causing growth, but instead can lead to protein malnutrition if consumed in isolation.
  • Examples: plant proteins (corn, lentils, beans, and nuts.)
    • Soy is one of the few examples of a plant protein that is considered complete!
An Overview of Protein and Amino Acid Metabolism

Dietary Protein

Gut

Amino acid pools in blood and body fluids

Absorption

Protein synthesis

Protein breakdown

Synthesis of non-essential amino acids from CHO and fat

Lost in feces

Lost in urine as urea

Converted to fat and/or CHO

Protein in body tissues (muscle, liver, kidneys, etc), hormones, enzymes, antibodies, N-containing derivatives of AAs
Dietary Protein Quality.

- Are some protein sources better than others?
- Different sources can very widely in their:
  - Amino Acid Profile (Leucine content)
  - Digestibility
  - Nutritional value

Four most common methods
1. Biological value (BV)
2. Net Protein Utilization (NPU)
3. Protein efficiency ratio (PER)
4. Protein Digestibility Corrected Amino Acid Score (PDCAAS).
The Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) define protein quality by assigning a Protein Digestibility Corrected Amino Acid Score (PDCAAS) to protein sources.

The primary quality component is digestibility, or the percentage of protein that is extracted from a protein source.

The second component of each PDCAAS is an amino acid score (AAS), which is calculated by dividing the limiting EAA in a protein source by the amount of this EAA contained in the reference protein and multiplying by 100.
## PDCAAS for Selected Proteins

<table>
<thead>
<tr>
<th>Protein Source</th>
<th>Digestibility</th>
<th>AAS</th>
<th>PDCAAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beans</td>
<td>78</td>
<td>102</td>
<td>80</td>
</tr>
<tr>
<td>Egg</td>
<td>97</td>
<td>121</td>
<td>118</td>
</tr>
<tr>
<td>Beef</td>
<td>98</td>
<td>94</td>
<td>92</td>
</tr>
<tr>
<td>Cow Milk</td>
<td>95</td>
<td>127</td>
<td>121</td>
</tr>
<tr>
<td>Brown Rice</td>
<td>88</td>
<td>66</td>
<td>58</td>
</tr>
<tr>
<td>Soy Protein</td>
<td>95</td>
<td>96</td>
<td>91</td>
</tr>
<tr>
<td>Wheat</td>
<td>86</td>
<td>40</td>
<td>34</td>
</tr>
</tbody>
</table>


Thing to remember is that if vegetarian, the quality of protein may be low in your diet requiring a greater protein consumption.
Protein absorption rates:

<table>
<thead>
<tr>
<th>Protein Source</th>
<th>Absorption rate (g·h^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg protein raw</td>
<td>1.3</td>
</tr>
<tr>
<td>Pea flour</td>
<td>2.4</td>
</tr>
<tr>
<td>Egg protein cooked</td>
<td>2.8</td>
</tr>
<tr>
<td>Pea flour: globulins &amp; albumins</td>
<td>3.4</td>
</tr>
<tr>
<td>Milk protein</td>
<td>3.5</td>
</tr>
<tr>
<td>Soy protein isolate</td>
<td>3.9</td>
</tr>
<tr>
<td>Free amino acids</td>
<td>4.3</td>
</tr>
<tr>
<td>Casein isolate</td>
<td>6.1</td>
</tr>
<tr>
<td>Free amino acids (same profile as casein)</td>
<td>7 - 7.5</td>
</tr>
<tr>
<td>Whey isolate</td>
<td>8 - 10</td>
</tr>
</tbody>
</table>

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Recommended Daily Allowance (RDA)

• The RDA for protein represents the amount necessary to maintain nitrogen balance and muscle mass under sedentary conditions.

• However, this amount is insufficient when physically active and trying to increase muscle mass or promote cardiovascular training adaptations.
Important Question on Protein Consumption: How much? degradation vs. accretion

Protein degradation < protein accretion = Positive nitrogen balance

Protein degradation > protein accretion = negative nitrogen balance
• Following resistance exercise in a fasted state muscle net protein balance is negative.

• Rate of breakdown exceeds rate of synthesis.
  • Biolo et al., 1995, Tipton et al., 1999

Adapted from Wolfe, 2006
The use of amino acids (via infusion or ingestion) stimulates protein synthesis. (Bohe et al., 2001, Volpi et al., 2000)

Stimulation is dependent upon dose and pattern of ingestion (bolus vs constant ingestion) (Wolfe, 2002)

Additive response of RE and AA administration (Biolo et al., 1995)

Greater anabolic response leading to greater potential for muscle remodeling

Adapted from Wolfe, 2006
Protein Needs

- 0.8 g·kg$^{-1}$
- 1.2 - 1.4 g·kg$^{-1}$
- 1.8 - 2.0 g·kg$^{-1}$
High Concentration of Dietary Protein

N = 12, randomly assigned to Protein or Control treatment groups
1.3 g protein·kg·d⁻¹ vs. 3.3 g protein·kg·d⁻¹
4 wks of resistance training

Results:
• The higher protein stimulated greater muscle growth
• Had positive protein balance and increase in AA acid oxidation

Conclusion: Positive nitrogen balance stimulates muscle growth

Experimental Design

• Strength trained (ST) and Sedentary (SED) male subjects randomly assigned to:
  
  LP - 0.86 g PRO·kg⁻¹·d⁻¹  
  MP - 1.40 g PRO·kg⁻¹·d⁻¹  
  HP - 2.40 g PRO·kg⁻¹·d⁻¹  

Remained on diet for 13 days
Nitrogen balance, whole body protein synthesis and leucine oxidation determined
**NITROGEN BALANCE (NBAL, mgN•kg\(^{-1}\)•d\(^{-1}\))**

**PROTEIN INTAKE (PRO\(_{IN}\), mgN•kg\(^{-1}\)•d\(^{-1}\))**

- **SED:** \(\text{NBAL} = -16.8 + 24.3(\text{PRO}_{IN})\)
- **ST:** \(\text{NBAL} = -71.6 + 50.9(\text{PRO}_{IN})\)

Effect of Protein Intake on Strength, Body Composition

- Participants were experienced resistance trained athletes (college football players, sprinters or throwers) with >2 y of resistance training experience.
- Participants performed the same resistance training program for 12 wk.
- Based upon the average weekly protein intakes participants were categorized into three groups;
  - Below recommended daily protein intake (BL; 1.0–1.4 g·kg\(^{-1}\)·day\(^{-1}\); n=8)
  - Recommended daily protein intake (RL; 1.6–1.8 g·kg\(^{-1}\)·day\(^{-1}\); n=7)
  - Above recommended daily protein intake (AL; >2.0 g·kg\(^{-1}\)·day\(^{-1}\); n=8)

<table>
<thead>
<tr>
<th>Group</th>
<th>Kcal</th>
<th>Kcal·BM(^{1})</th>
<th>CHO (g)</th>
<th>Protein (g)</th>
<th>Total Protein (g·kg(^{-1}))</th>
<th>Fat (g)</th>
<th>% CHO</th>
<th>% Protein</th>
<th>% Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>BL</td>
<td>3181 ± 462</td>
<td>31.9 ± 3.1</td>
<td>449 ± 89</td>
<td>118 ± 18</td>
<td>1.19 ± 0.14</td>
<td>102 ± 11.7</td>
<td>56.6 ± 4.3</td>
<td>15.0 ± 2.6</td>
<td>28.9 ± 3.1</td>
</tr>
<tr>
<td>RL</td>
<td>3127 ± 522</td>
<td>33.6 ± 5.4</td>
<td>394 ± 69</td>
<td>160 ± 20</td>
<td>1.74 ± 0.13</td>
<td>106 ± 31</td>
<td>50.3 ± 4.6</td>
<td>21.2 ± 3.5</td>
<td>30.0 ± 5.0</td>
</tr>
<tr>
<td>AL</td>
<td>3200 ± 773</td>
<td>33.6 ± 7.6</td>
<td>335 ± 118</td>
<td>224 ± 57</td>
<td>2.36 ± 0.44</td>
<td>109 ± 23</td>
<td>41.0 ± 6.5</td>
<td>28.6 ± 4.5</td>
<td>30.8 ± 4.0</td>
</tr>
</tbody>
</table>

BL = below recommended protein intake; RL = recommended protein intake; AL = above recommended protein intake. * = significantly different (p < 0.05) than BL; ** = significantly different (p < 0.05) than RL.
Performance Changes

Changes in LBM and Squat Strength

∆ Changes in LBM and Squat Strength

Changes in Bench Press Strength

* = sig different vs RL

Hoffman et al., JISSN, 2006
Effect of Protein Supplementation on Δ Changes in LBM and Strength

- College football players
- 12 week protein supplementation during off-season conditioning.
- Placebo group (PL; n=10, 1.24 ± 0.12 g·kg⁻¹)
- Protein group (PR; n=11, 2.00 ± 0.12 g·kg⁻¹)

Hoffman et al., JSSM, 2007
Super High Daily Protein Intakes

• Compare 2.3 and 3.4 g·kg·day⁻¹ of dietary protein per day with an 8-week resistance training program (5-day per week split routine) in resistance trained men and women.

• Normal protein: n = 17 (4 women and 13 men)

• High protein; n = 31 (7 women and 24 men)

• HP group lost an average of 1.6 kg of fat mass versus 0.3 kg in the NP group.

• % body fat decrease was −2.4 % and −0.6 % in the HP and NP groups respectively.

No Significant Differences noted in strength (squat, bench press) or power (vertical and broad) measures and 13 men.

Antonio et al., 2016
Protein intakes between 1.6 and 2.0 g·kg$^{-1}$·day$^{-1}$ are recommended for strength/power athletes to maintain a positive nitrogen balance. Evidence for greater daily intakes in strength/power athletes does exist.
leading dietetic and sports medicine organizations generally take a conservative approach to supplementation. Consensus among these organizations is that protein needs can generally be met through food intake.
Protein Supplementation

- Organizations also acknowledge the role that protein and amino acids have in optimizing the training response and enhancing recovery, and how the timing of ingestion may provide significant benefits.

- The most convenient and efficient method for providing immediate protein needs to enhance recovery may be through supplementation.
Benefits of Protein Supplementation

Recent studies have shown that protein supplementation can:

- Decrease muscle damage
- Attenuate force decrements
- Enhance recovery

(Hoffman et al., 2008, Kraemer et al., 2006, Ratamess et al., 2003)
Data from 22 randomized controlled studies that included 680 participants were included in the analysis.

The inclusion criteria for consideration was that each study have a supplementation group that consumed a minimum of 1.2 g·kg·day\(^{-1}\) of protein taken in combination with a prolonged resistance training program of at least 6-weeks or longer.

Results revealed that protein supplementation in combination with resistance training can significantly augment the gains in lean body mass, cross-sectional area of both type I and type II muscle fibers and strength.

These results appeared to be consistent for both younger (23 ± 3 y) and older (62 ± 6 y) adults.
Forest Plot of Meta-Analysis Shown as Pooled Mean Differences with 95% CI on Fat Free Mass

For each study, the shaded circle represents the point estimate of the intervention effect. The horizontal line joins the lower and upper limits of the 95% CI of this effect. The area of the shaded circles reflects the relative weight of the study in the meta-analysis. The diamonds represent the subgroup mean difference (◊) and pooled mean difference (◆).
Protein Source
Protein Source

Animal protein

- The common animal proteins typically found in protein supplements include whey, casein and bovine colostrum.

Vegetable protein

- To provide for all of the essential amino acids various types of vegetable proteins need to be combined.
- Popular sources include legumes, nuts and soy.
- One advantage of vegetable protein is a likely reduction in the intake of saturated fat and cholesterol.
- Soy, from the legume family, is the most widely used vegetable protein source.
- Soy is a complete protein with a high concentration of branched chained amino acids.
Protein Intake: Whole Protein Comparison of Casein and Whey

• From bovine milk with different digestive properties.
• Casein; predominant milk protein, exists in the form of a micelle (large colloidal particle)
  • Slow to digest
  • Provides a slow, but sustained release of amino acids into blood
• Whey: translucent part of bovine milk (~20%), with high concentration of BCAA and EAA.
  • Absorption rate much faster than casein.
Total Leucine Oxidation

30g feeding of casein and whey.

↑ protein synthesis by 68%

↑ protein synthesis by 31%

7 hrs post: casein intake resulted in higher (p<0.05) leucine balance

Boirie et al., (1997)
Casein vs. whey

- Casein and whey are both effective in stimulating muscle protein synthesis.
  - Casein and whey are complete proteins with different amino acid composition.
  - Leucine is higher in whey than casein.
  - Differences in digestive properties also contribute to differences in rates of muscle protein synthesis.

- Whey provides a greater acute response.
- A greater window of opportunity following exercise for enhanced recovery and muscle remodeling.
Comparison of Casein and Whey Protein Ingestion: Net Protein Balance

- 23 male and female subjects (5yrs resistance training)
- 3 supplemental groups (1 hr after exercise)
  - Flavored water
  - 20g of Casein
  - 20g of Whey
- Exercise Protocol: 10 sets - 8 reps leg extension at 80% of 1RM
- Both Casein and/or Whey Proteins can boost the anabolic effect of resistance exercise.
- Whey though provided a greater effect!
- Window of Adaptation??

Tipton et al., 2004
Stimulus to muscle

Window of Adaptation
The Effects of Soy and Whey Protein Supplementation on Amino Acid Responses to Resistance Exercise in Men

Volek et al. 2013

Table 1. Nutritional Composition of Supplements

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Carbohydrate</th>
<th>Whey</th>
<th>Soy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kcal)</td>
<td>191</td>
<td>194</td>
<td>189</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>45.2</td>
<td>22.5</td>
<td>24.5</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>0.8</td>
<td>21.6</td>
<td>20.4</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>0.8</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Saturated fat (g)</td>
<td>0.3</td>
<td>1.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>201</td>
<td>189</td>
<td>214</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>2.1</td>
<td>2.0</td>
<td>4.4</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>44</td>
<td>114</td>
<td>213</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>154</td>
<td>183</td>
<td>402</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>18</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>55</td>
<td>164</td>
<td>78</td>
</tr>
<tr>
<td>Amino acid composition (mg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alanine</td>
<td>—</td>
<td>1050</td>
<td>726</td>
</tr>
<tr>
<td>Arginine</td>
<td>—</td>
<td>667</td>
<td>1329</td>
</tr>
<tr>
<td>Aspartic acid</td>
<td>—</td>
<td>2029</td>
<td>1835</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>—</td>
<td>3519</td>
<td>3262</td>
</tr>
<tr>
<td>Glycine</td>
<td>—</td>
<td>409</td>
<td>674</td>
</tr>
<tr>
<td>Histidine</td>
<td>—</td>
<td>405</td>
<td>447</td>
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<tr>
<td>Isoleucine</td>
<td>—</td>
<td>592</td>
<td>372</td>
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<tr>
<td>Leucine</td>
<td>—</td>
<td>221</td>
<td>1372</td>
</tr>
<tr>
<td>Lysine</td>
<td>—</td>
<td>1918</td>
<td>1097</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>—</td>
<td>703</td>
<td>904</td>
</tr>
<tr>
<td>Proline</td>
<td>—</td>
<td>1181</td>
<td>810</td>
</tr>
<tr>
<td>Serine</td>
<td>—</td>
<td>1126</td>
<td>856</td>
</tr>
<tr>
<td>Threonine</td>
<td>—</td>
<td>1442</td>
<td>671</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>—</td>
<td>652</td>
<td>651</td>
</tr>
<tr>
<td>Valine</td>
<td>—</td>
<td>1140</td>
<td>794</td>
</tr>
</tbody>
</table>

*Values are per serving (packet). Subjects consumed one packet per day.

After 9 months Whey 30%> CHO and 45%> Soy for LBM Gain
Soy vs. Whey Protein

• No significant differences were noted between the groups in the change in 1-RM bench press or squat strength.
• However, the change in lean body mass was significantly higher in whey than soy following 3-, 6- and 9-months of training.
• Fasting leucine concentrations were significantly elevated (20%) and post-exercise plasma leucine increased more than 2-fold in the whey group.
Soy vs. Whey

• An additional study compared soy and whey protein supplementation in resistance trained men.

• Participants consumed 20 g of either soy or whey on a daily basis for two weeks. Following the supplementation period, participants performed 6 sets of 10 repetitions of the squat exercise at 80% of the participant’s 1-RM.

• Participants consuming the soy protein were shown to have an attenuated testosterone response to an acute training program, while whey may blunt the cortisol response to exercise.

Kraemer et al. 2013
Importance of Leucine
Leucine

• Leucine threshold - Theoretical minimum dose of leucine required to stimulate an increase in muscle protein synthesis. (Drummond et al. 2009; Tang et al. 2009)

• Leucine Saturation - Theoretical minimal single oral dose of leucine required to maximally stimulate muscle protein synthesis (Katsanos et al. 2005; Leutholtz 2005; Tipton et al 1999)
Theoretical Leucine Threshold

% Change Protein Synthesis

Grams of Leucine

Trained vs. Untrained
The diagram illustrates the intracellular leucine concentration over time for different protein sources:

- **Whey**
- **Soy**
- **Casein**

The graph shows a 'trigger' point for muscle protein synthesis, with peaks indicating the time of maximum leucine concentration for each protein type. The x-axis represents time in minutes (0, 60, 180), and the y-axis represents intracellular leucine concentration.
# Leucine Saturation

*From these sources of protein 20 to 30g are needed maximize MPS for Untrained And 15 to 20g for Trained! Important for meal planning. ~25g each meal goal.*

<table>
<thead>
<tr>
<th>Source</th>
<th>% Leu</th>
<th>Untrained (grams needed)</th>
<th>Trained (grams needed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>8.0%</td>
<td>~26g</td>
<td>~17.5g</td>
</tr>
<tr>
<td>Chicken</td>
<td>7.5%</td>
<td>~28g</td>
<td>~19g</td>
</tr>
<tr>
<td>Egg</td>
<td>8.6%</td>
<td>~24g</td>
<td>~16g</td>
</tr>
<tr>
<td>Fish</td>
<td>8.1%</td>
<td>~26g</td>
<td>~17g</td>
</tr>
<tr>
<td>Milk</td>
<td>9.8%</td>
<td>~21g ~21oz</td>
<td>~14g ~14oz ~2cups</td>
</tr>
<tr>
<td>Whey</td>
<td>12.0%</td>
<td>~17.5g</td>
<td>~12g</td>
</tr>
<tr>
<td>Soy Milk</td>
<td>6.77%</td>
<td>~31.0g ~31 oz</td>
<td>~21g ~21 oz ~2.6 cups</td>
</tr>
</tbody>
</table>

Protein Type Summary

- Present understanding appears to support the use of milk, or animal-based proteins to maximize muscle protein synthesis and changes in lean body mass.
  - Likely related to differences in protein quality as milk proteins contain a greater concentration of leucine.
- Further research appears warranted whether soy ingestion attenuates the anabolic response to exercise.
Timing of Protein Ingestion
Comparison of pre vs post exercise EAA + CHO intake

Pre-exercise ingestion of EAA: Increased rate of delivery and subsequent uptake by skeletal muscle

Tipton et al., 2001

Pre-exercise EAA ingestion resulted in 160% greater amino acid uptake by skeletal muscle

<table>
<thead>
<tr>
<th>Phe delivery (nmol/min x 100ml/LV)</th>
<th>PRE</th>
<th>POST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rest</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>Exercise</td>
<td>2200</td>
<td>2200</td>
</tr>
<tr>
<td>1-h Post-Ex</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>2-h Post-Ex</td>
<td>500</td>
<td>500</td>
</tr>
</tbody>
</table>
Type of Amino Acid: Essential versus Nonessential

• Only essential amino acids necessary for stimulation of protein synthesis
• Leucine and Isoleucine appear to have the greatest effect on muscle protein synthesis.
• Increases in protein synthesis occurs with greater amounts of EAA ingestion.
• Is there a ceiling effect?
ESSENTIAL VS NONESSENTIAL AMINO ACIDS AND MUSCLE PROTEIN SYNTHESIS (Volpi et al., 2003)

- Compare Essential amino acids (18 g) to balanced amino acids (18 g EAA and 22 g non-EAA) in healthy elderly men.
- Given in small boluses every 10 min for 3 hr.

- EAA essential for muscle protein anabolism.
- Non-EAA do not provide any additional benefits regarding muscle protein synthesis in this subject population.
Evidence for Acute benefits of protein timing
15 male strength/power athletes divided into protein and BCAA blend consumed 10 min prior to and 15 min following the workout.

Subjects 4 sets of 80% of 1-RM the squat, dead lift and barbell lunge exercises. 90-s rest interval between each set.

Subjects performed 4 sets of the squat exercise, using the same loading pattern and rest interval 24- and 48 h post.

Hoffman et al., Amino Acids, 2009
Training Studies
Protein Timing in Recreational Bodybuilders

- Young recreationally trained bodybuilders (~21 - 24 y).
- Whey (40 g) + CHO (43 g Glucose) in consumed immediately before and after (Pre/Post) vs. Morning/Evening (am/pm)
- 10 week study.
- Daily protein intake 1.92 g·kg\(^{-1}\) and 2.11 g·kg\(^{-1}\) in Pre/Post and am/pm, respectively.

Cribbs and Hayes, 2006
1-RM Squat

Cribbs and Hayes, 2006
1-RM Bench Press

Week 0

Pre/Post

Week 10

Cribbs and Hayes, 2006
Lean Body Mass

Cribbs and Hayes, 2006
Cross-sectional area of Type IIa fibers

* = significant difference between pre/post and morn/even. Data adapted from Cribbs and Hayes, 2006
* = significant difference between pre/post and morn/even. Data adapted from Cribbs and Hayes, 2006
Study Summary

• First study to show benefit of protein timing on both muscle hypertrophy and strength gains in young, athletic population.
Effect of amino acid supplementation during resistance training overreaching

Kraemer et al., 2006

**Squat**

<table>
<thead>
<tr>
<th>Amino Acid Supplement (per tablet)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>L-Leucine</td>
<td>250 mg</td>
</tr>
<tr>
<td>L-Lysine</td>
<td>130 mg</td>
</tr>
<tr>
<td>L-Isoleucine</td>
<td>125 mg</td>
</tr>
<tr>
<td>L-Valine</td>
<td>125 mg</td>
</tr>
<tr>
<td>L-Threonine</td>
<td>70 mg</td>
</tr>
<tr>
<td>L-Cysteine</td>
<td>30 mg</td>
</tr>
<tr>
<td>L-Histidine</td>
<td>30 mg</td>
</tr>
<tr>
<td>L-Phenylalanine</td>
<td>20 mg</td>
</tr>
<tr>
<td>L-Methionine</td>
<td>10 mg</td>
</tr>
<tr>
<td>L-Tyrosine</td>
<td>6 mg</td>
</tr>
<tr>
<td>L-Tryptophan</td>
<td>4 mg</td>
</tr>
</tbody>
</table>

**Bench Press**  Δ change

- 4
- 3.5
- 3
- 0

- 17 resistance trained men
- 0.4 g/kg per day of amino acid supplement
- Overreaching resistance training program 3 sets of 8 exercises (8 - 12 repetitions)
- 4 week training program
BCAA Role in Fatigue

- BCAA’s have been demonstrated to have an important role in protein synthesis and enhance recovery.
- Several studies have suggested that BCAA may also improve cognition and psychomotor function.
- The mechanisms relating to improved cognition is related to changes in amino acid concentrations within the brain.
- During periods of high stress and fatigue the use of BCAA may counteract or delay fatigue by decreasing the concentration of tryptophan and thus the synthesis of serotonin and may have an important role in potential performance decrements during sustained or prolonged exercise.
Effect of Protein Timing in Experienced Strength/Power Athletes:

- 33 College football players assigned to am/pm (n = 13) or pre/post feedings (n = 13).
  - 42 g protein (enzymatically hydrolyzed collagen protein isolate, whey protein isolate and casein protein isolate).
- 7 participants served as controls (no protein supplement feedings).
- 10 week study (hypertrophy and strength phases).

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Weeks 1–5 (Sets × Reps)</th>
<th>Weeks 5–10 (Sets × Reps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days 1 and 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>high pull</td>
<td>—</td>
<td>4 × 4–6</td>
</tr>
<tr>
<td>bench press</td>
<td>4 × 8–10</td>
<td>4 × 6–8</td>
</tr>
<tr>
<td>incline bench press</td>
<td>3 × 8–10</td>
<td>3 × 6–8</td>
</tr>
<tr>
<td>incline flies</td>
<td>3 × 8–10</td>
<td>3 × 6–8</td>
</tr>
<tr>
<td>seated shoulder press</td>
<td>4 × 8–10</td>
<td>—</td>
</tr>
<tr>
<td>dumbbell shoulder press/behind-the-neck</td>
<td>—</td>
<td>4 × 6–8</td>
</tr>
<tr>
<td>shoulder press</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>lateral raises/dumbbell front raise</td>
<td>3 × 8–10</td>
<td>3 × 6–8</td>
</tr>
<tr>
<td>triceps push-downs</td>
<td>3 × 8–10</td>
<td>3 × 6–8</td>
</tr>
<tr>
<td>triceps push-downs/dumbbell extensions</td>
<td>3 × 8–10</td>
<td>3 × 6–8</td>
</tr>
<tr>
<td>partner neck exercise</td>
<td>2 × 10</td>
<td>3 × 10</td>
</tr>
<tr>
<td>Days 2 and 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>squat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dead lift/Romanian dead lift</td>
<td>4 × 8–10</td>
<td>4 × 6–8</td>
</tr>
<tr>
<td>dumbbell lunge/dumbbell step-ups</td>
<td>3 × 8–10</td>
<td>3 × 6–8</td>
</tr>
<tr>
<td>leg curls</td>
<td>3 × 8–10</td>
<td>—</td>
</tr>
<tr>
<td>standing calf raises</td>
<td>4 × 8–10</td>
<td>3 × 6–8</td>
</tr>
<tr>
<td>pull-ups</td>
<td>3 × max</td>
<td></td>
</tr>
<tr>
<td>lat pull-down</td>
<td>4 × 8–10</td>
<td>4 × 6–8</td>
</tr>
<tr>
<td>seated row</td>
<td>4 × 8–10</td>
<td>4 × 6–8</td>
</tr>
<tr>
<td>dumbbell biceps curls</td>
<td>4 × 8–10</td>
<td>4 × 6–8</td>
</tr>
<tr>
<td>trunk and abdominal routine</td>
<td>3 × 10</td>
<td>3 × 10</td>
</tr>
</tbody>
</table>

*Note.* All exercises performed to a repetition-maximum range. Lines with two exercises required the athlete to perform the first exercise during the first training session and the second exercise during the second training session.
Experienced Strength/Power Athletes: 1RM Squat


All groups in positive nitrogen balance with no difference
Experienced Strength/Power Athletes: 1RM Bench Press

No Changes seen in any anthropometric measures: Body mass, LBM, Body fat % and fat mass.
Conclusion

• Total daily protein intake may have a stronger effect than when its consumed in competitive strength/power athletes - during short duration studies.

• Evidence is more convincing for the acute effects regarding protein timing and competitive athlete: \textit{window for enhancing recovery}.

• Longer duration studies are necessary to examine this specific question regarding protein timing in competitive athletes.
HOW MUCH PROTEIN SHOULD BE CONSUMED PER INGESTION?
Protein Ingestion Pattern and Whole Body Protein Turnover in Resistance Trained Men (Moore et al., Nutr. Metab, 2012)

- Seven, resistance trained men provided three different dosing patterns:
  - Pulse (8 x 10 g of whey protein every 1.5 h).
  - Intermediate (4 x 20 g every 3 h).
  - Bolus (2 x 40 g every 6 h)

- Ingestion occurred following an acute bout of knee extension exercise (4 x 10 @ 80%1RM)

Means with different letters are significantly different (P<0.05) according to one-way ANOVA with Student-Newman Keuls post-hoc.
A skewed daily protein distribution fails to maximize potential for muscle growth or maintenance.

**Daily protein distribution**
- *typical?*

<table>
<thead>
<tr>
<th>Protein Distribution</th>
<th>Anabolism</th>
<th>Catabolism</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>65 g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Protein**
90 g

Maximum rate of protein synthesis
“Leucine Saturation”
Daily protein distribution
- Optimal -

- Catabolism
- Anabolism

Maximum rate of protein synthesis
Leucine Threshold

25 g
25 g
25 g

Total Protein
75 g

Repeated maximal stimulation of protein synthesis
→ increase / maintenance of muscle mass
Daily protein distribution

- **Optimal** -

- Anabolism

  - Post-Exercise
    - 25g

- Catabolism

  - Resistance Exercise

- Maximum rate of protein synthesis
- Leucine Threshold
- Resistance Exercise + Nutrition

Repeated maximal stimulation of protein synthesis

→ increase / maintenance of muscle mass

Total Protein

100g
Conclusion

• The benefits of elevating protein intake in trained athletes are well accepted.
• Most dieticians would emphasize the use of dietary protein to achieve these goals; however, the ability to provide protein at specific time points surrounding the workout may be best achieved from a supplement.
• Recent emphasis on the importance of protein timing is interesting with some evidence to support its efficacy.
• Data though is not conclusive in regards to the experienced athlete and recent information strongly indicates the importance of multiple protein feedings per day to maintain a sustained elevation of muscle protein synthesis.
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Thank you!

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