SOY PROTEIN AND MUSCLE PROTEIN SYNTHESIS

By Jared M. Dickinson, PhD

Skeletal muscle accounts for ~40% of body weight and contains 50–75% of body proteins. In addition to being the most abundant tissue in the body, skeletal muscle serves a fundamental role for a variety of biological needs. For instance, skeletal muscle is imperative for force production and movement, and increases in skeletal muscle mass are often associated with improvements in strength, function, and performance. Skeletal muscle also serves as the primary site for glucose disposal and acts as a reservoir for amino acids that function as precursors for immune function during injury and illness. Consequently, the loss of muscle mass not only compromises physical function, but it predisposes individuals to greater risk for injury and illness, longer recovery, and increased susceptibility to chronic disease.

Changes in skeletal muscle mass are governed by the interplay between muscle protein synthesis (MPS) and muscle protein breakdown. In particular, a chronic imbalance favoring one process over the other facilitates an increase (synthesis > breakdown) or decrease (breakdown > synthesis) in muscle mass. Protein synthesis and breakdown are both continuous processes that fluctuate up and down throughout the day, particularly in response to exercise/physical activity and nutrients. However, in the non-diseased state, changes in MPS are of much greater magnitude than those of breakdown suggesting that skeletal muscle mass is principally impacted by the

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Soy Protein and Muscle Protein Synthesis

Mounting evidence, including the above findings, suggests that more emphasis should be placed on meal-based protein recommendations rather than a daily requirement. For instance, in the U.S. a majority of daily protein intake appears to occur during the dinner/evening meal with lower quantities ingested at breakfast and lunch (www.ars.usda.gov/ba/bhnrc/fsrg). Thus, an individual with a daily RDA for protein of 70g could reach the recommended protein intake by ingesting 10g at breakfast, 15g at lunch and 45g at dinner. While this strategy would satisfy the RDA, it would not provide a maximal stimulus for MPS after each meal, and the higher protein meal is not able to compensate for the lower protein meals. Consequently, this feeding schedule may not completely offset the increased breakdown between meals, ultimately leading to a loss of muscle over time. Conversely, distributing protein intake across three meals, each consisting of ~25–35g of some mixture of high-quality proteins (perhaps 30–35g for older adults), could maximize MPS after each meal and appropriately offset periods of catabolism. Indeed, a recent study found that for an identical total daily protein intake, 24-hr MPS was greater when protein was distributed among meals as compared to ingesting it all at one meal.

Ingesting proper amounts of any high-quality protein, such as soy, whey, and casein, stimulates skeletal MPS at rest and following exercise.

EAAs, such as soy, whey, and casein, should provide an ideal potential stimulus to increase MPS. In both young and older adults ~10g of EAs, containing ~2g of leucine, has been shown to maximally stimulate MPS in the rested state (no prior exercise). Accounting for differences in the content of EAAs and leucine, ingesting ~25–35g of any high-quality protein should provide a maximal stimulus for healthy adults at rest. In fact, the increase in MPS after ingesting 30g of protein is similar to that after ingesting 90g of protein (beef protein), indicating that even large protein meals do not further stimulate MPS. However, one study does indicate that if soy is the sole protein source, older adults may require greater than 30g at rest to maximally stimulate MPS, perhaps due to the lower leucine content in soy. However, additional research is necessary to confirm such findings.
to a protein distribution skewed towards greater intake at the evening meal.  

Exercise results in a powerful stimulus to increase MPS. Exercise results in a sustained increase in MPS, however, the magnitude of the stimulatory effect of exercise on MPS is less than that of protein ingestion. In fact, in order to stimulate an anabolic environment within the exercised muscle (synthesis > breakdown), exercise must be coupled with postexercise protein/amino acid ingestion. The coupling of exercise with protein ingestion appears more critical for stimulating protein synthesis in older adults, and compared to young individuals, older adults may require greater amounts of protein following exercise to maximally stimulate MPS.  

Studies have recently focused on optimizing nutritional strategies to maximize postexercise MPS, mostly following resistance exercise. These studies have shown that in young adults, postexercise MPS is enhanced when coupled with the ingestion of appropriate quantities (20–30g) of a high-quality protein source (soy, whey, casein). However, some reports indicate that various protein sources do not necessarily have the same stimulatory effect. For instance, when ingesting 20g of protein following exercise, whey and soy protein have been shown to have a greater stimulatory effect on MPS for the first three hours following exercise compared to casein. However, casein is a slowly digested protein that results in a slow, sustained entry of amino acids into circulation, whereas whey and soy are digested faster, resulting in higher concentrations and earlier availability of amino acids. Thus, reported discrepancies in the ability for these protein sources to stimulate postexercise MPS may be related, in part, to the timing of the measurement of MPS following exercise. In fact, differences in postexercise MPS between casein and whey ingestion appear to be eliminated when the measurement of MPS is extended to six hours postexercise. Similarly, reports also indicate that ~20g of whey/milk protein has a greater stimulatory effect in the immediate hours after exercise compared to ~20g of soy. However, whey protein contains ~25% more leucine compared to soy, and leucine is critical for the stimulation of postexercise MPS. Thus, these reported discrepancies on postexercise MPS between soy and dairy protein sources may be due to the lower leucine content of soy, particularly when ingesting lower quantities of soy (~20g) that may not provide enough leucine. Further research is needed to determine whether ingesting ~25% more soy compared to whey, to match the leucine content (as opposed to matching total protein), eliminates the reported discrepancies between protein sources on postexercise MPS.  

The effect of ingesting a protein blend on postexercise MPS was recently examined. The study was predicated on animal research indicating that ingesting a protein blend consisting of 25% soy, 25% whey, and 50% casein prolongs MPS compared to a single protein source. Young adults completed a bout of resistance exercise and one hour after exercise ingested either ~19g of the protein blend or ~18g of whey (matched for total leucine). Skeletal MPS increased in both groups, however, ingesting the protein blend prolonged the increase in circulating amino acids and postexercise MPS. Thus, a protein blend consisting of soy, whey, and casein may take advantage of the intrinsic characteristics of each protein source (absorption rate, leucine content) and promote a prolonged anabolic environment for skeletal muscle. In summary, ingesting proper amounts of any high-quality protein, such as soy, whey, and casein, stimulates skeletal MPS at rest and following exercise. While the stimulatory effects of these protein sources on postexercise MPS are reported to differ, careful consideration should be made for ensuring appropriate quantities of leucine are ingested (~2g), rather than matching total protein ingestion (particularly between soy and whey). Similarly, given the lower content of leucine in soy, older adults may require greater amounts of ingested soy protein (and perhaps casein) to stimulate MPS as compared to a protein source with higher leucine. Recent data indicate that a protein blend, consisting of soy, whey, and casein, may provide advantages over the ingestion of a single source protein for the stimulation of postexercise MPS, which could promote additional health benefits related to the intrinsic properties of the protein sources. Lastly, with respect to maximizing the impact of protein ingestion on MPS, dietary recommendations should be less focused on a daily protein intake, and instead focus on consuming ~25–30g (perhaps 30–35g for older adults) of some mixture of high-quality protein per meal.

**ABOUT THE AUTHOR**

**Jared Dickinson, PhD** is Assistant Professor at Arizona State University. His research interests are focused on understanding the mechanisms that contribute to the loss of muscle size and function with aging (i.e., sarcopenia) and how exercise and nutrition can be utilized to improve muscle health in older adults and clinical populations. He received his postdoc from the University of Texas Medical Branch, his PhD from Ball State University, his master’s degree from Central Washington University and his bachelor’s degree from Pacific University.

Complete references for articles can be found at www.soyconnection.com
DIETARY INTERVENTIONS IN THE PREVENTION AND MANAGEMENT OF SARCOPENIA

By Joan Trabal, RD

Sarcopenia has been defined as a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength with a risk of adverse outcomes such as physical disability, poor quality of life and death.¹ In the United States, the direct costs of sarcopenia have been estimated to be $18.5 billion.² The reported prevalence of sarcopenia in the United States is 22.6% and 26.8% for women and men, respectively.³ Several pathophysiological mechanisms have been associated with the etiology of sarcopenia, from decreased physical activity,⁴ to disruption in the regulation of muscle protein turnover.⁵ Progressive resistance exercise is still considered the most effective treatment to stimulate muscle hypertrophy, increase strength, and improve physical performance in older adults.⁶ However, the role of diet in the prevention and management of sarcopenia has also been researched. Protein-energy malnutrition can contribute to the onset and development of sarcopenia. For instance, hand grip strength has been shown to correlate with total body protein loss.⁷ Therefore, guaranteeing an adequate intake of energy and high-quality protein will be one of the key features of a dietary intervention targeting sarcopenia.

Protein turnover is integral to muscle health, and aged muscle has been shown to have a lower response to the anabolic stimuli of amino acids and exercise, compared to young muscle.⁸⁹ This concept is referred to as anabolic resistance.¹⁰ This blunted protein synthesis response to amino acid intake has been seen when small doses (<7g) of essential amino acids (EAA) are provided at each meal.¹¹ However, larger amounts of EAA (>10g) have been shown to result in similar responses in protein synthesis in muscle from both aged and young individuals.¹² This increased response elicited by EAA would be mediated by activating the mTOR signaling pathway.¹³ Observational data show that dietary protein intake is inversely associated with loss of lean mass, and a decreased risk of frailty.¹⁴¹⁵

Human intervention studies with protein or amino acid supplementation, with or without resistance training, have shown inconsistent results regarding increases in muscle mass, strength and function.¹⁶¹⁷ But in a recent meta-analysis of protein supplementation intervention studies in conjunction with resistance training, pooled data showed an overall positive effect of protein supplementation on fat free mass and leg strength in older adults, when compared with a placebo.¹⁸ These results show that an increase in protein intake, alongside resistance training, is necessary to optimize muscle growth and increase strength.

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Sarcopenia: Disease, Syndrome, or Natural Part of Aging?

It has been defined as the loss of skeletal muscle mass and strength that occurs with advancing age. However, a widely accepted definition of sarcopenia suitable for use in research and clinical practice is still lacking.

In 1989, Irwin Rosenberg proposed the term ‘sarcopenia’ (Greek ‘sarx’ or flesh + ‘penia’ or loss) to describe age-related decrease of muscle mass. Nevertheless, sarcopenia has no broadly accepted clinical definition, consensus diagnostic criteria, International Classification of Diseases 9th Revision (ICD-9) codes or treatment guidelines. The European Working Group on Sarcopenia in Older People recently recommended recognizing sarcopenia as a geriatric syndrome because this view promotes its identification and treatment even when the exact causes remain unknown. This group also recommends that for the diagnosis of sarcopenia, the presence of both low muscle mass + low muscle function (strength or performance) be present.
Late afternoon stomach rumbling? Long meeting before lunch? It’s easy to keep energy up and hunger at bay by eating a snack high in protein. Protein-rich snacks will keep you feeling full longer than a less nutritious food like a pack of cookies, chips or a candy bar.

Snacks, especially those composed of nutrient-dense foods, can be an important part of a person’s diet. Snacking helps spread total daily calories across the day, which in turn can help keep blood sugar under control. Those who try to avoid snacking may tend to overeat at the following meal.

It’s best to eat snacks because you are hungry, not out of boredom or a sense of obligation to “eat healthy.” What’s more, snacks of nutritious proteins (such as those listed below) provide additional health promoting nutrients like fiber, vitamin D, calcium and various micronutrients. Roasted, dried and freeze-dried edamame (green soybeans) are available in many sweet and savory flavors at most grocery stores.

A reasonable snack should contain around 200 calories, which fits easily into a day’s total calorie count. As with meals, portion control for snacks is key. Prepare several small containers of ¼ to ½ cup portions to stow in the fridge at work, take along in the car, or pop in a tote bag. Your snack will be with you and ready to eat between your business appointments, your classes, or during travel times.

### EASY PROTEIN SNACKS

By Chezna Warner, PA-C, MHS, MSW and Christine Werner, PhD, PA-C, RD

<table>
<thead>
<tr>
<th>Food Group</th>
<th>Calories (cal)/standard serving size</th>
<th>Protein/serving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry roasted soy nuts</td>
<td>140 cal per ¼ cup</td>
<td>12 grams</td>
</tr>
<tr>
<td>Fresh edamame (steamed or boiled)</td>
<td>125 cal per ½ cup (shelled)</td>
<td>11 grams</td>
</tr>
<tr>
<td>Dry roasted almonds</td>
<td>205 cal per ¼ cup</td>
<td>7 grams</td>
</tr>
<tr>
<td>Roasted chickpeas</td>
<td>180 cal per ½ cup</td>
<td>7 grams</td>
</tr>
<tr>
<td>Hard-boiled egg</td>
<td>78 cal (1 large egg)</td>
<td>6.3 grams</td>
</tr>
<tr>
<td>Soy milk</td>
<td>90 cal per 8 oz. cup</td>
<td>6 grams</td>
</tr>
<tr>
<td>Nut butters (soy, peanut, almond)</td>
<td>188 cal per 2 tbsp</td>
<td>8 grams</td>
</tr>
<tr>
<td>Pumpkin seeds, raw</td>
<td>126 cal per tbsp</td>
<td>8 grams</td>
</tr>
<tr>
<td>Mozzarella cheese sticks</td>
<td>80 cal per 1 oz. stick</td>
<td>5 grams</td>
</tr>
<tr>
<td>Yogurt, Greek, plain</td>
<td>100 cal per 8 oz. cup</td>
<td>17 grams</td>
</tr>
</tbody>
</table>

**Edamame trail mix:**

1 cup almonds  
1 cup walnuts  
½ cup dried cranberries  
½ cup sunflower seeds  
½ cup dark chocolate chips  
2 cups dried roasted edamame

Mix all in a large container. A ¼ cup portion has approximately 180 calories and 6.8 grams of protein.

### ABOUT THE AUTHORS

**Chezna Warner, PA-C, MHS, MSW,** is a family medicine physician assistant with SLUCare Physician Group and an assistant professor in the Saint Louis University Department of Physician Assistant Education. Her clinical and research interests include promotion of plant-based diets to improve weight management and diabetes outcomes.

**Christine Werner, PhD, PA-C, RD,** is a professor at Saint Louis University in the department of Physician Assistant Education where she teaches nutrition, cardiology and evidence-based medicine. Dr. Werner’s areas of research interest include evidence-based clinical practice in nutrition and medical therapy.
The latest recommendations for the optimal level of protein intake state that to maintain physical function, older people should consume an average daily intake in the range of 1.0–1.2g protein/kg body weight/d, and for those with acute or chronic conditions, the range should be 1.2–1.5g protein/kg body weight/d. For those who exercise, a total daily intake of at least 1.2g protein/kg body weight is recommended. Regarding the protein intake distribution pattern, some researchers recommend consuming protein evenly distributed throughout the day (i.e., 25–30g of protein at each of the three main meals), in order to maximize muscle protein synthesis throughout the day.

The consumption of high-quality proteins such as soy protein help to maximize muscle protein synthesis. In fact, the consumption of soyfoods and other legumes ≥3 times per day has been associated with a significantly reduced risk of inability to perform activities of daily living in older women.

Vitamin D also seems to play a role on muscle function through different genomic and non-genomic actions. Low levels of vitamin D have been associated with increased risk of sarcopenia and frailty. It may be advisable for those older adults with low circulating levels of vitamin D to use supplements with either vitamin D2 or D3, or fortified foods, to raise levels above 100 nmol/L. Both isoforms of this vitamin are equally effective. Studies have shown that daily supplementation of 800–1000 IU of vitamin D improves muscle strength.

Limited research on muscle synthesis exists with other nutrients, such as fatty acids. Recent human studies have observed that supplementation with long chain omega-3 fatty acids increases the rate of muscle protein synthesis, as well as enhances the effects of resistance training on strength and function in older adults. The mechanisms involved in the effects of these fatty acids on the aged muscle are not completely understood, but they seem to be related to an attenuation of anabolic resistance.

Like other age-related conditions, sarcopenia has the potential to be mitigated by a healthy lifestyle and diet. However, a better understanding of precisely how diet impacts the risk of development and management of sarcopenia is needed.
References

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