PROTEIN REQUIREMENTS & ROLE IN MUSCLE PROTEIN SYNTHESIS

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OVERVIEW

- The role of protein in the body
- Regulation of muscle protein synthesis (MPS)
- Protein quality

PROTEINS IN THE BODY

PROTEIN AND THE BODY

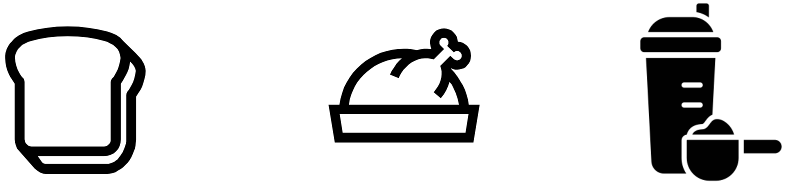
- Structure
- Movement
- Immune function
- Transport
- Hormones
- Enzymes
- Cell signaling

PROTEIN REQUIREMENTS

National Academy of Medicine
(Formerly the Institute of Medicine)

0.8 g/kg/d

Adults > 18 years



Varying sources

PROTEIN REQUIREMENTS

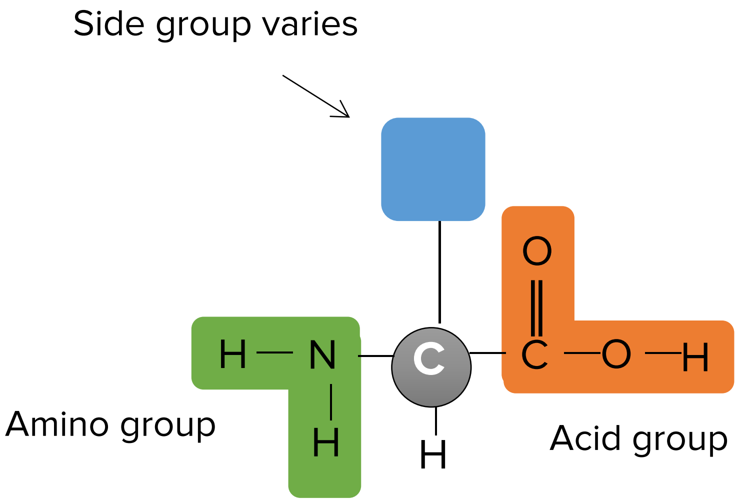
Daily Intake Guidelines for Athletes

TEAM SPORTS	1.2-1.7 G/KG/D
ENDURANCE	1.2-1.4 G/KG/D
STRENGTH	1.6-1.7 G/KG/D
POWER	1.5-1.7 G/KG/D

Slater & Phillips. J Sport Sci. 29(Suppl 1):S67-77, 2011.
Stellingwerff et al. J Sport Sci. 29(Suppl 1):S79-89, 2011.
Joint Position Statement: Nutrition and Athletic Performance. Med Sci Sports Exerc. 48:543-68, 2016

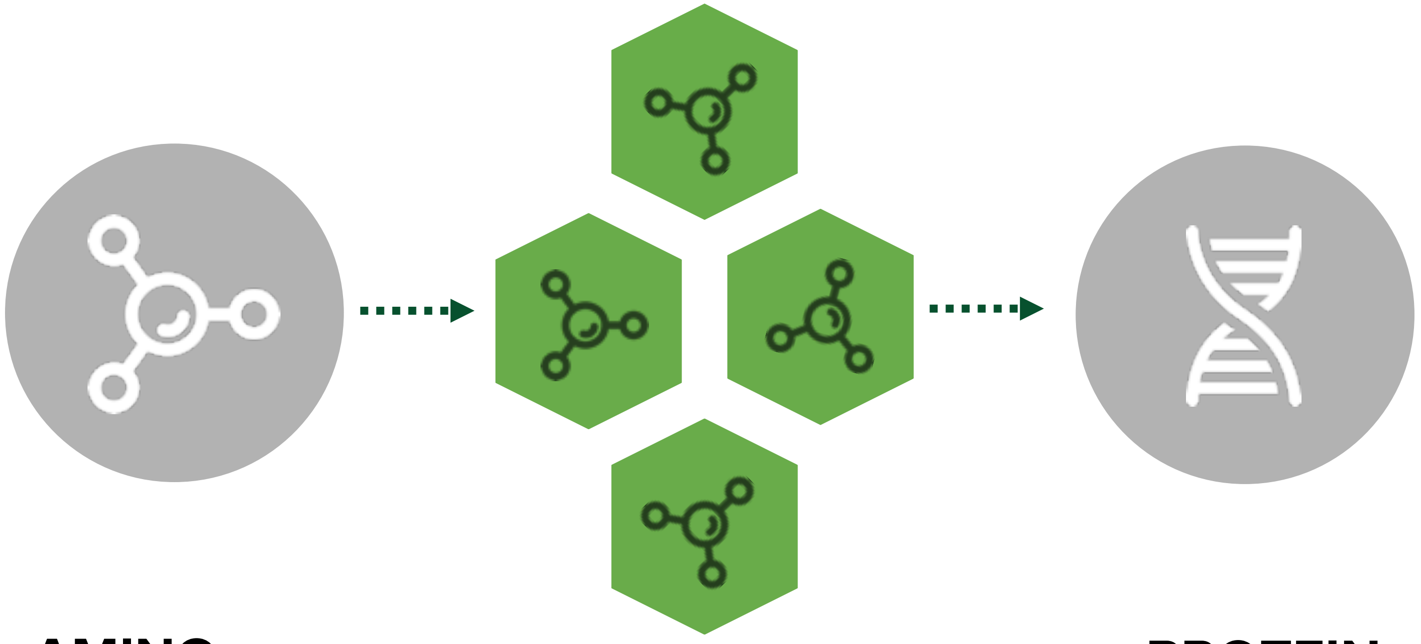
Why do you think protein intake guidelines are higher for athletes than the RDA?

AMINO ACID BUILDING BLOCKS



Side group = Functional differences of AA

Amino Acid Structure



AMINO ACID

nitrogen-containing organic molecule

AMINO ACIDS BOND TOGETHER

PROTEIN

CLASSES OF AMINO ACIDS

ESSENTIAL

- Histidine
- Isoleucine
- Leucine
- Lysine
- Methoinine
- Phenylalanine
- Threonine
- Tryptophan
- Valine

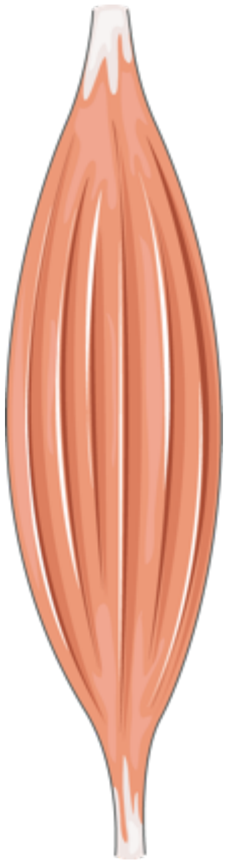
NON-ESSENTIAL

- Arginine
- Asparagine
- Aspartic Acid
- Glutamic Acid

CONDITIONAL

- Arginine
- Cysteine
- Glutamine
- Glycine
- Tyrosine
- Ornithine
- Proline
- Serine

PROTEIN IN THE HUMAN BODY



>40% of body mass is skeletal muscle

Collagen is the most abundant protein in the body (25-35%)

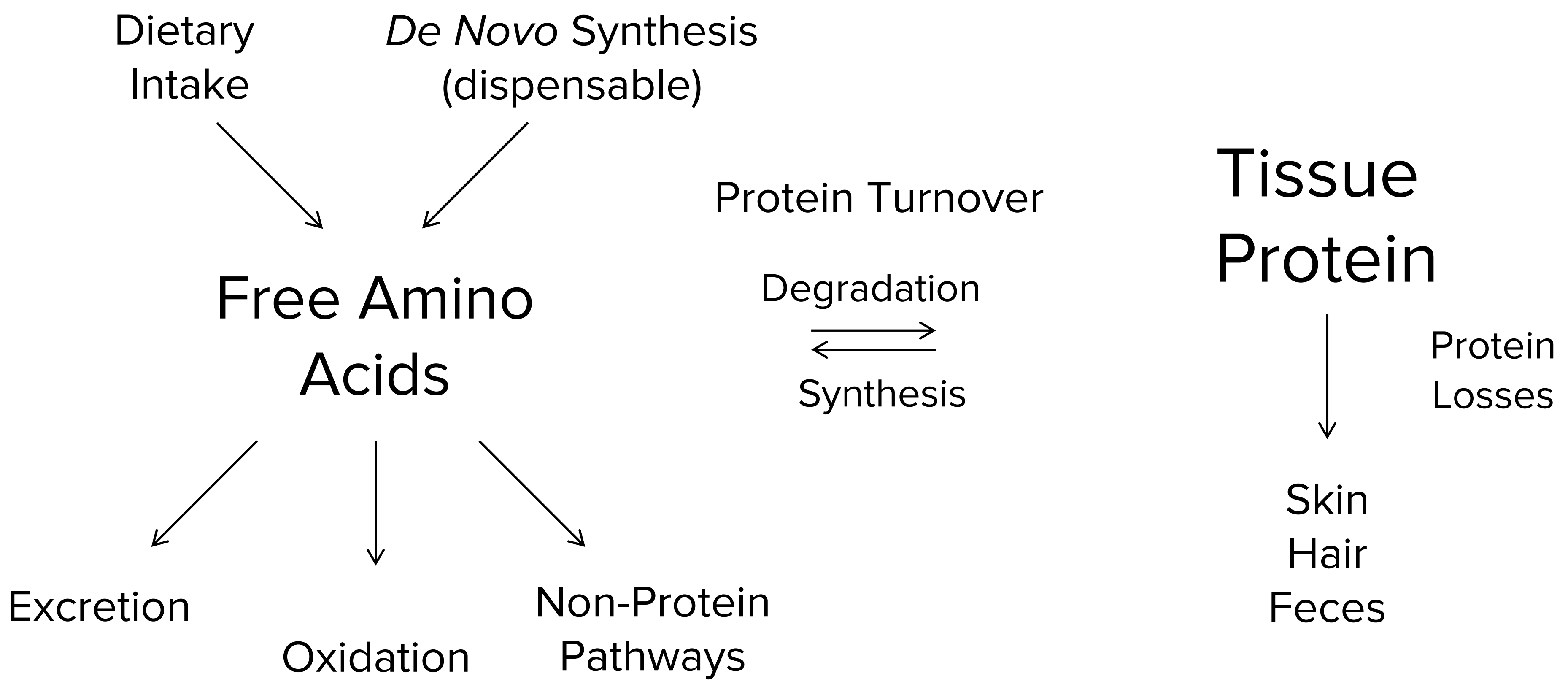
There is no protein storage site in the body (unlike glucose or fat)

Consuming protein regularly is important to ensure there are adequate AAs to replenish pools

Urea is the principal vehicle for excreting unused nitrogen

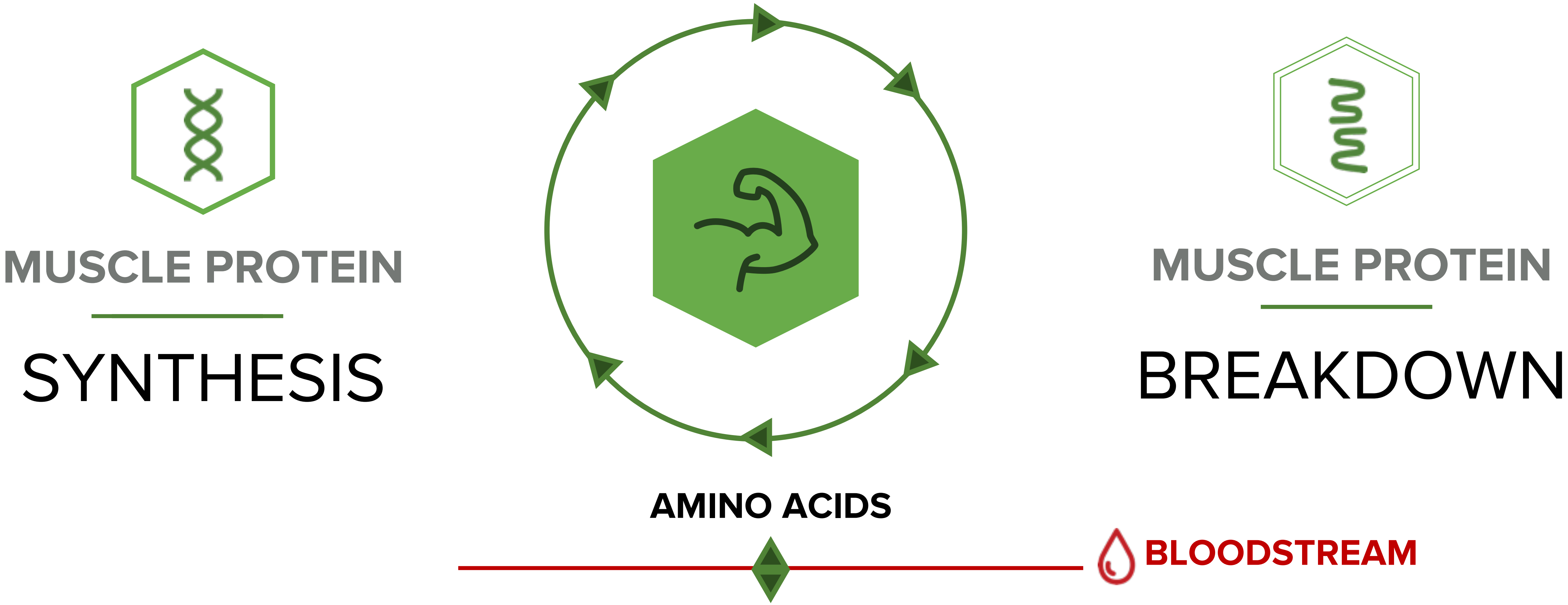
MUSCLE PROTEIN TURNOVER: MPS & MPB IN REGULATING MUSCLE SIZE

Muscle Protein Turnover- the Amino Acid Pools



Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. Institute of Medicine. 2005

MUSCLE PROTEIN TURNOVER



MUSCLE PROTEIN TURNOVER

	SYNTHESIS	BREAKDOWN
Hypertrophy (growth)	>	<
Atrophy (loss)	<	>

MUSCLE PROTEIN TURNOVER

There are 2 main drivers to muscle protein synthesis:

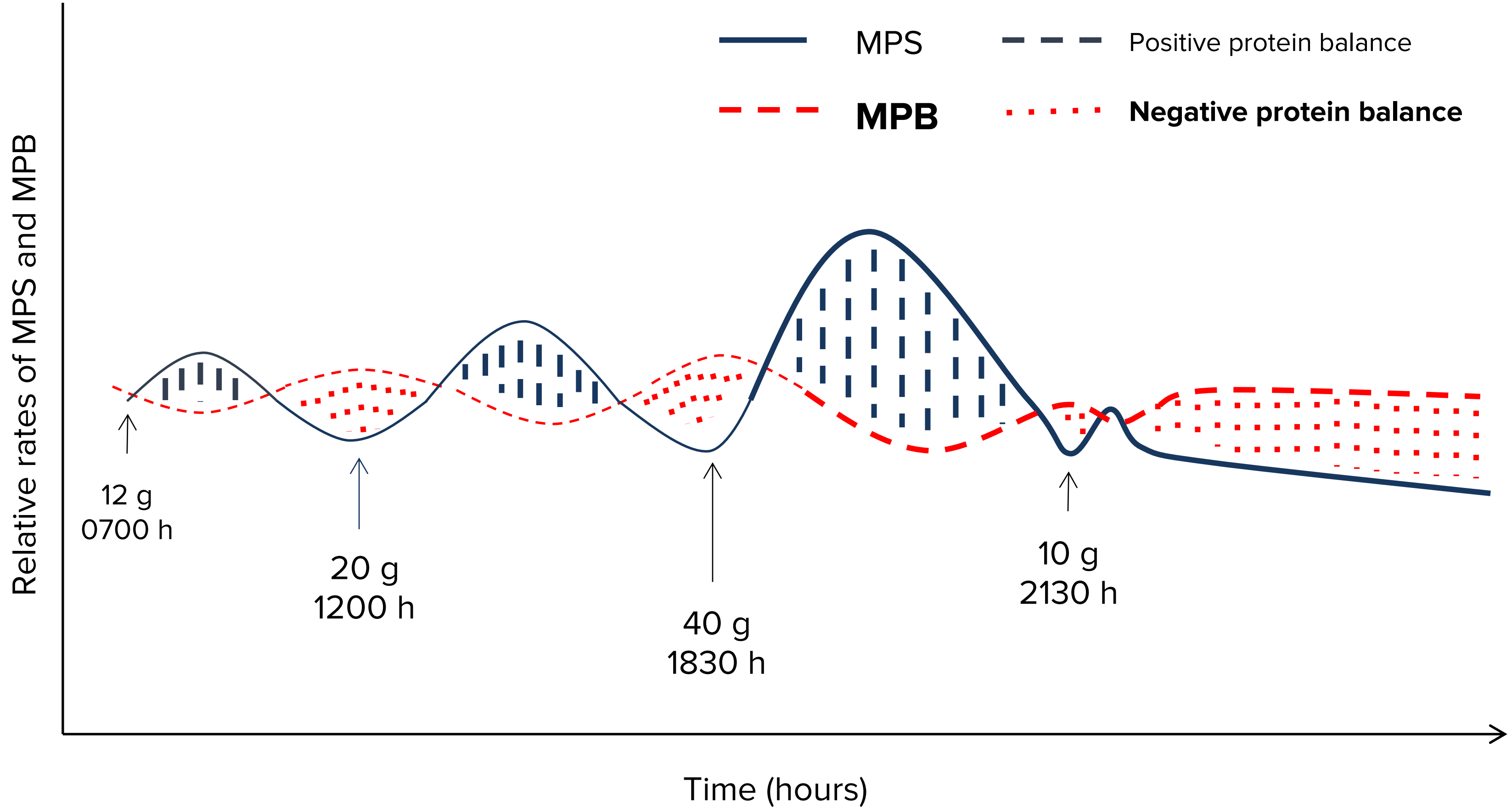
Protein Ingestion

Muscle Damage/Exercise

Biolo G, Maggi SP, Williams BD, et. al. *Am J Physiol Endocrinol* Metab. 1995;268(3):E514-E520
Biolo G, Tipton KD, Klein S, et. al. *Am J Physiol Endocrinol Metab.* 1997;273:E112-E129

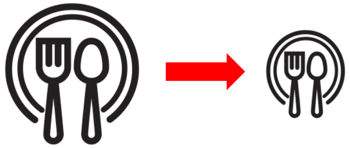
Why do we go into NEGATIVE protein balance?

Periods of **negative protein balance** are typically less than or equal to periods of positive protein balance.



But we can **induce negative protein balance** by:

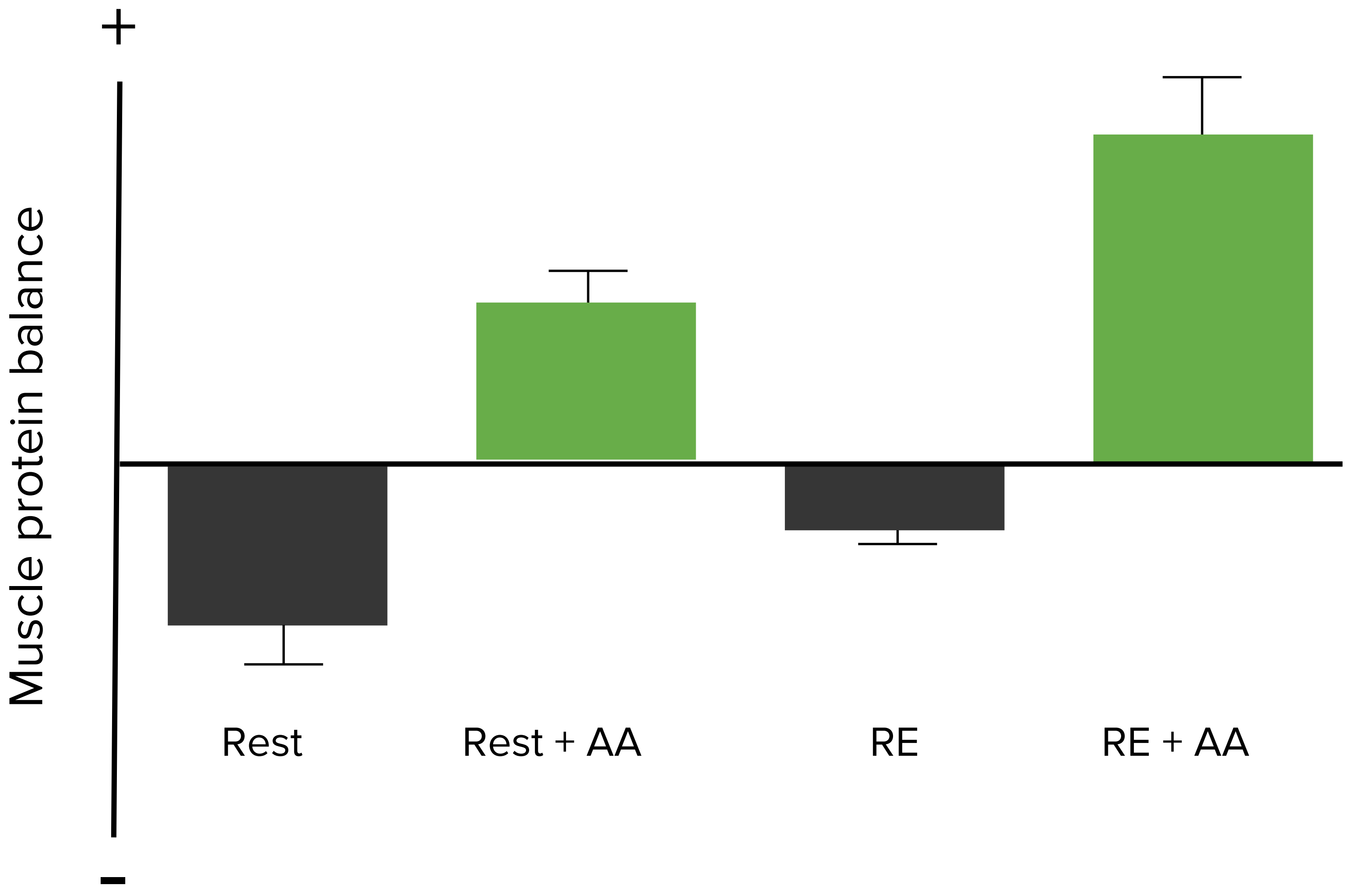
1. **Calorie restricting**



2. **Bed rest/hospitalization**

MUSCLE PROTEIN TURNOVER

What are the effects of amino acids and exercise on MPS?

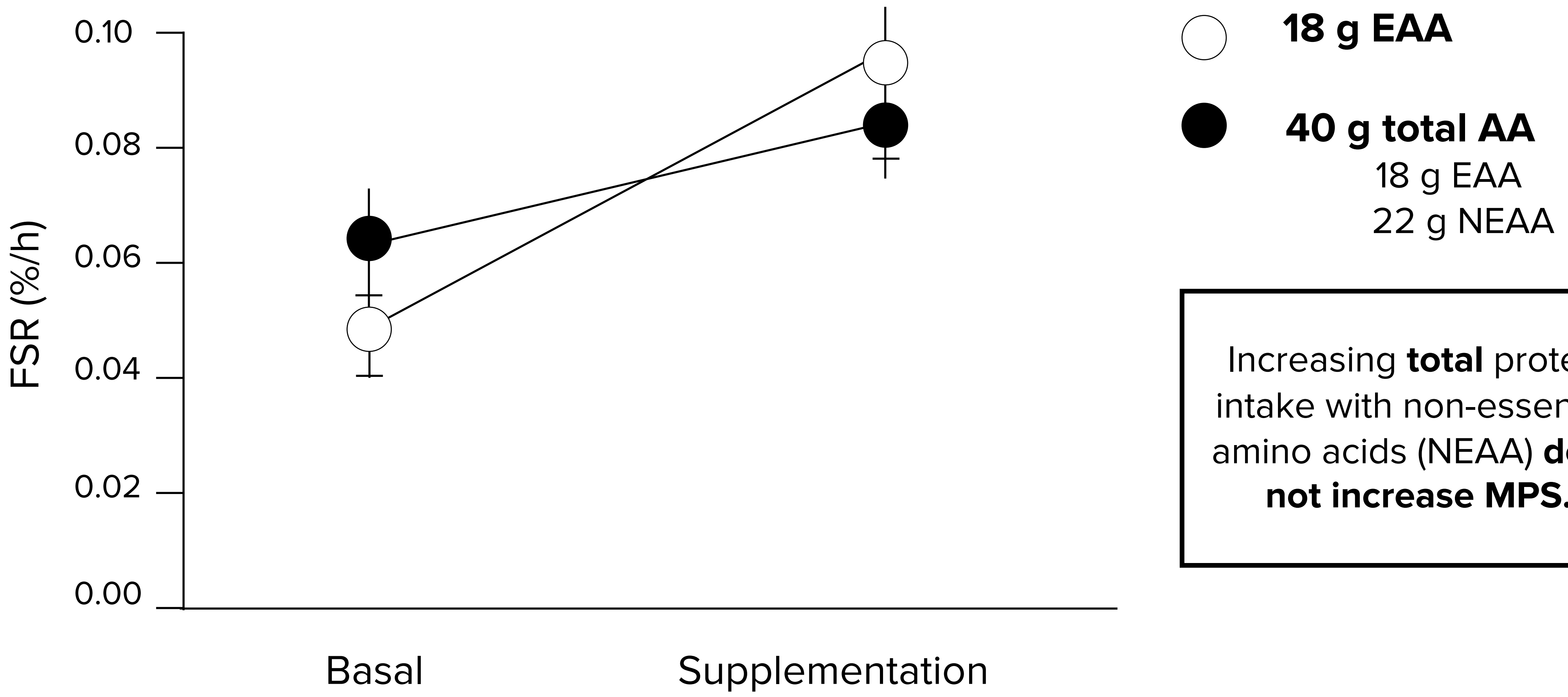


Both amino acids (AA) and resistance exercise (RE) can stimulate MPS.

When combined, they act **synergistically** to increase MPS.

Biolo G, Maggi SP, Williams BD, et. al. *Am J Physiol Endocrinol* Metab. 1995;268(3):E514-E520
Biolo G, Tipton KD, Klein S, et. al. *Am J Physiol Endocrinol Metab.* 1997;273:E112-E129

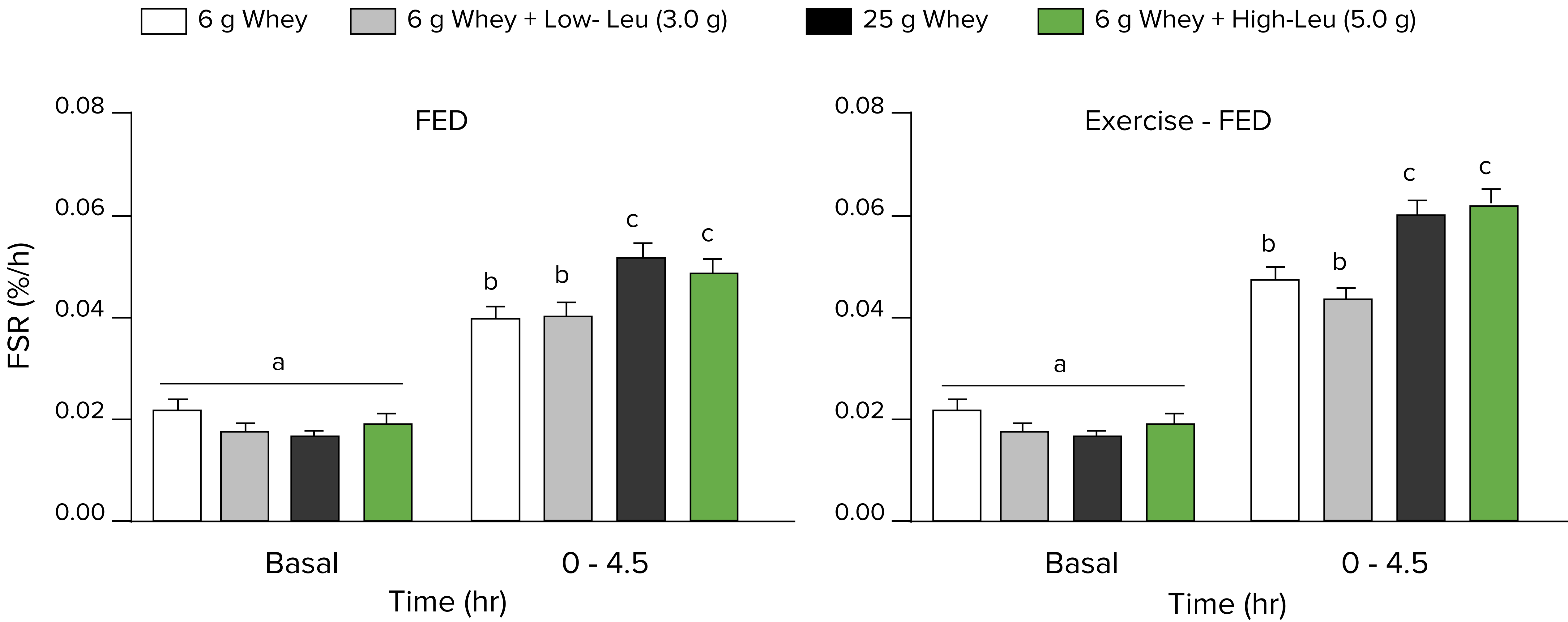
Essential Amino Acids Drive MPS



Increasing **total** protein intake with non-essential amino acids (NEAA) **does not increase MPS.**

MUSCLE PROTEIN SYNTHESIS

Leucine as the Primary Driver of MPS



Adapted from Churchward Venne TA, Breen L, Di Donato DM, et. al. *Am J Clin Nutr*. 2014;99:276–286

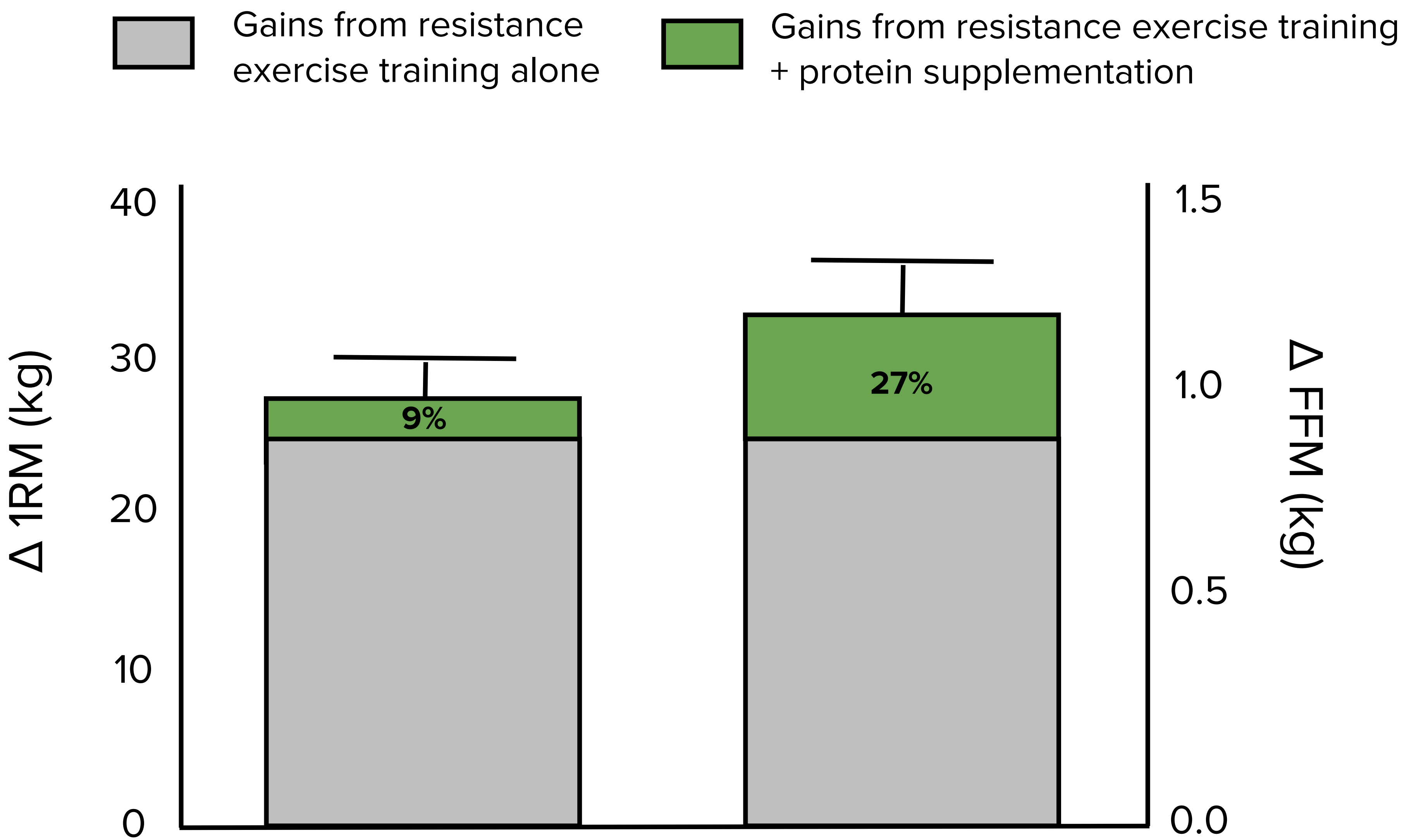
Leucine as the Primary Driver of MPS

What these data show is that with feeding alone and with feeding + exercise, 6 g of whey protein with added leucine resulted in similar stimulation of MPS to 25 g of whey protein alone.

Leucine drivesthe increase in MPS in the absence of elevated levels of other EAA.

Adapted from Churchward Venne TA, Breen L, Di Donato DM, et. al. *Am J Clin Nutr*. 2014;99:276–286

Does protein supplementation impact strength?



PROTEIN QUALITY: WHAT DOES IT MEAN? HOW DO WE ASSESS IT?

Protein Quality - the PDCAAS

Protein quality is determined by:

- Availability
- Digestibility
- Amount of essential amino acids

FAO and FDA use the Protein Digestibility-Corrected Amino Acid Score:

$$\text{PDCAAS \%} = \frac{\text{mg of limiting AA in 1 g of the protein}}{\text{mg of the same AA in 1 g of the reference protein}} \times \text{true fecal digestibility (\%)} \times 100$$

Scores: 0 - 1

Dietary protein quality evaluation in human nutrition, Report of an FAO Expert Consultation, FAO Food and Nutrition Paper 92. 2011

Protein Quality- the DIAAS

More recently, the FAO has adopted the Digestible Indispensible Amino Acid Score (DIAAS) as the preferred method to evaluate protein quality.

$$\text{DIAAS\%} = \frac{\text{mg of digestible indispensible AA in 1 g of the protein}}{\text{mg of the same indispensible AA in 1 g of the reference protein}} \times 100$$

Scores: 0 +

DIAAS VS. PDCAAS

The change in assessment from the PDCAAS to the DIAAS were several fold:

The PDCAAS does not give **extra credit to the highest quality proteins** since it truncates values at 1.

The PDCAAS method **overestimates protein quality** of products containing antinutritional factors.

The PDCAAS method does not adequately take into account the bioavailability of amino acids.

The PDCAAS method overestimates the quality of poorly digestible proteins supplemented with limiting amino acids, and of proteins co-limiting in more than one amino acid.

Bacterial degradation occurs with fecal digestibility **enhances protein quality scores.**

Dietary protein quality evaluation in human nutrition, Report of an FAO Expert Consultation, FAO Food and Nutrition Paper 92. 2011

Examples of Proteins Scored by the PDCAAS vs. DIAAS

Food	PDCAAS	DIAAS	Limiting AA
Milk protein concentrate	1.00	1.18	Met + Cys
Whey protein Isolate	1.00	1.09	Val
Soy protein Isolate	0.98	0.90	Met + Cys
Pea protein concentrate	0.89	0.82	Met + Cys
Rice protein concentrate	0.42	0.37	Lys
Whole Milk	1.00	1.14	Met + Cys
Chicken breast	1.00	1.08	Trp
Egg (hard boiled)	1.00	1.13	His
Cooked Peas	0.60	0.58	Met + Cys
Cooked Rice	0.62	0.59	Lys
Corn-based cereal	0.08	0.01	Lys
Hydrolyzed collagen	0.00	0.00	Trp

Table adapted from Phillips SM. *Frontiers.* 2017

Gram per gram is like comparing apples and oranges:

25 g whey protein isolate
3.6 g leucine

25 g collagen peptides
0.8 g leucine

25 g soy protein isolate
2.0 g leucine

To achieve the same amount of leucine

113 g of collagen peptides
(4.5 x more)

45 g of soy protein isolate
(1.8 x more)

COMPLIMENTARY PROTEINS

Limiting amino acids in Plant Foods

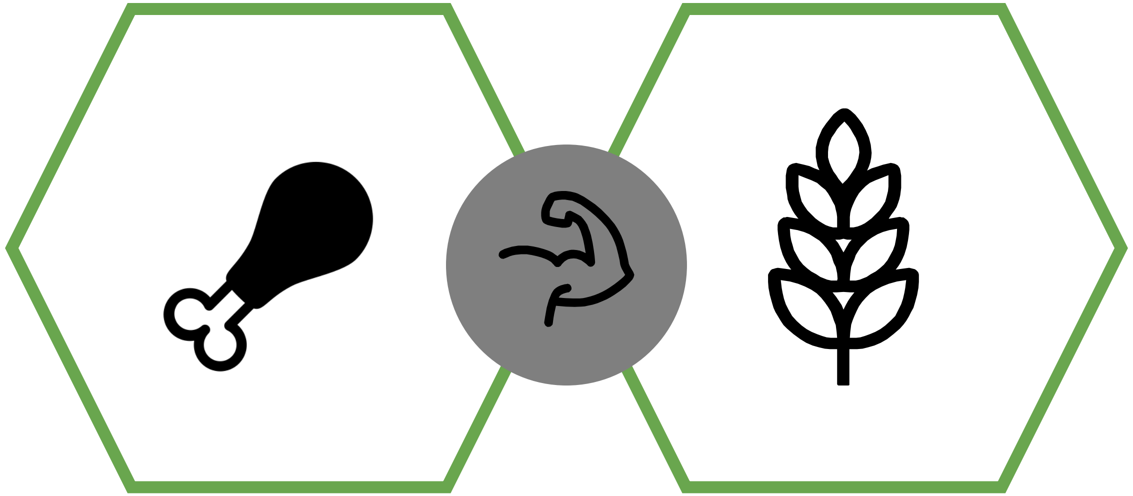
Food	Limiting AA	Plant source of the AA	Combination in which the proteins compliment
Legumes (beans)	Met	Grains, nuts, seeds	Red beans and rice
Vegetables	Met	Grains, nuts, seeds	Green beans and almonds
Grains	Lys, Thre, Trp	Legumes	Rice and red beans; lentils and rice; corn and beans
Nuts and Seeds	Lys	Legumes	Soybeans and sesame; peanuts, rice, and black-eyed peas

ANIMAL VS PLANT PROTEINS

Often complete proteins (collagen is the exception).

Contain high amounts of leucine.

Options for low fat selections.



Can achieve amino acid goals with complimentary proteins.

Often contain low levels of leucine.

Flexible for vegetarian/vegan diets.

Good idea to compare supplemental protein based on grams of EAA rather than absolute grams of total protein (similar to our apples and oranges slide).

SSE#188

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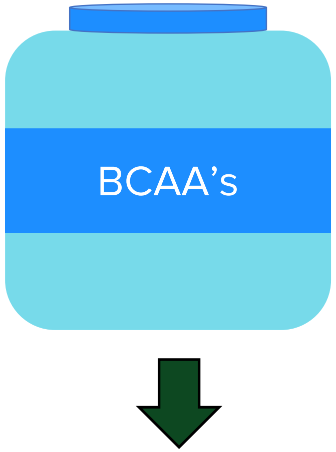
BRANCHED CHAIN AMINO ACIDS (BCAA)

There are 3 branched chain amino acids (BCAA's):



Leucine
Isoleucine
Valine

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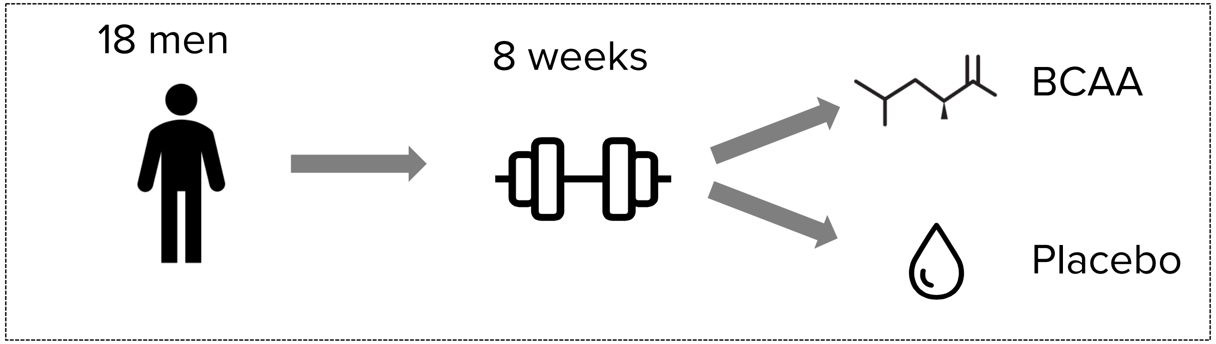
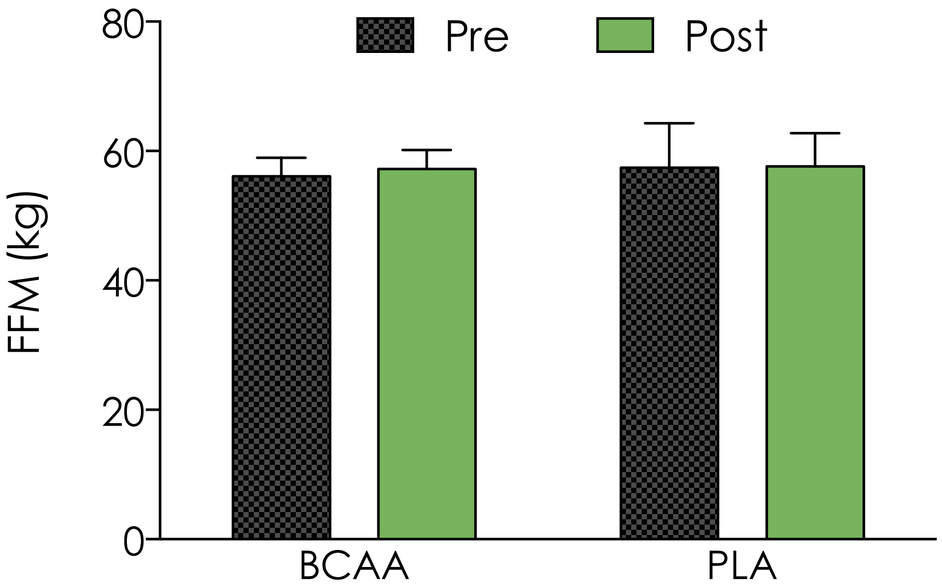
BCAA's Don't Enhance Muscle Growth





Spillane M, Emerson C, Willoughby DS. *Nutr & Heath.* 2012;21(4):263-273

HMB

β-hydroxy-β-methylbutyrate (HMB) and muscle growth

HMB is a metabolite derived from **leucine:**

- HMB is formed naturally when the body breaks down leucine.
- Suggested to boost muscle mass during resistance exercise.
    - Concurrently with losses in fat mass.
- Has been purported to reduce MPB.
- Comes in both a free acid (HMB-FA) and calcium form (HMB-Ca).

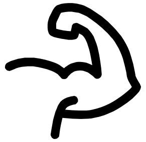
Meta analysis

302 male participants

18-45 years

Training 2-5 days/week

4-12 weeks training



Mean difference between HMB and placebo = was 0.29 kg

No difference between groups in fat mass changes

Jakubowski JS, Nunes EA, Teixeira FJ, et. al. *Nutrients.* 2020;12(5):1523

WHOLE FOOD VS SUPPLEMENTAL PROTEIN

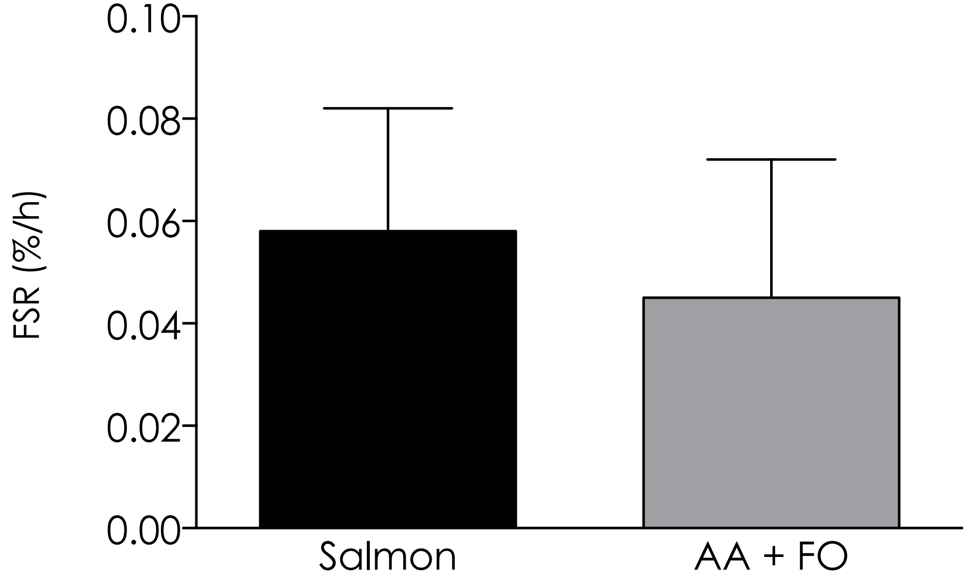
Food Matrix:

- Describes the overall physical form of food.
- Includes how food components are structured and interact.
- Processing and heat treatment also impact the food matrix to modulate digestibility.

SSE#194

VS.

Consuming salmon and its AA make up + fish oil = similar MPS response!

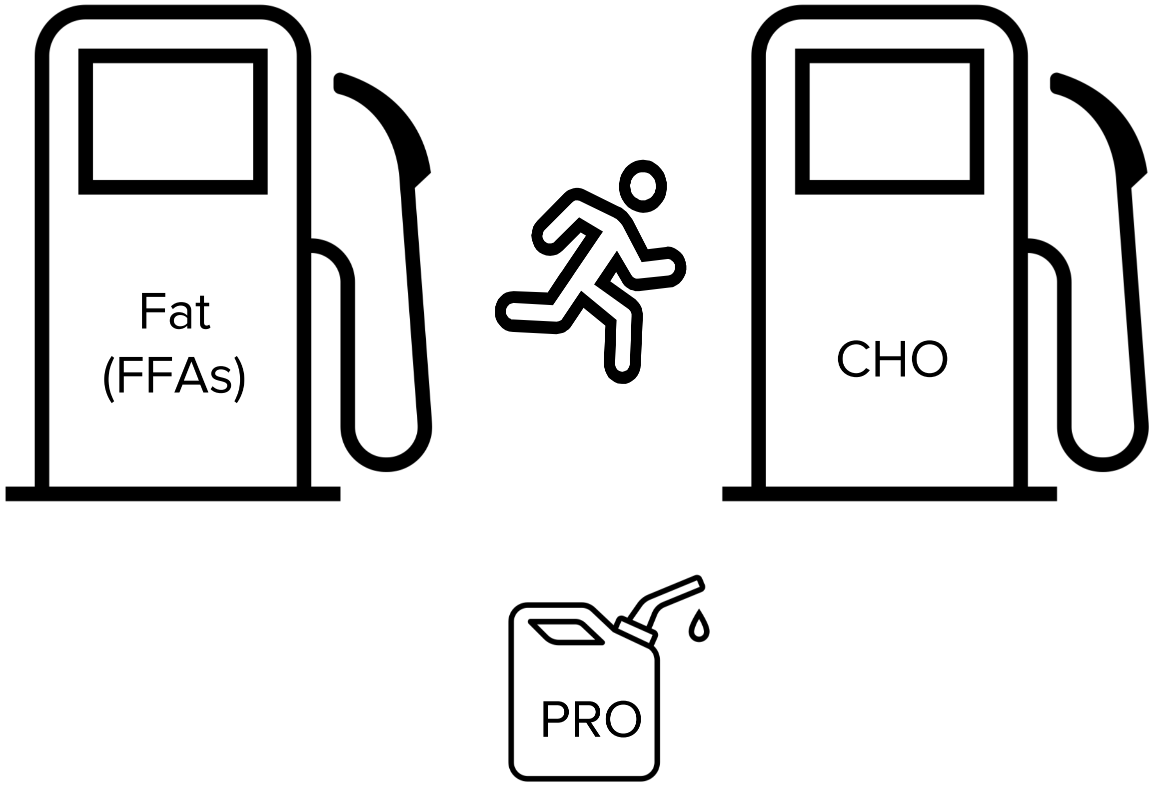


Paulussen K, Slavado A, McKenn C, et. al. *Curr Dev Nutr.* 2020;4(2):650
Burd NA, McKenna C, Skinner S, et. al. *Sports Science Exchange.* 2019;29(194)1-5

PROTEIN DURING EXERCISE

Protein as a Fuel Source During Exercise

- Occurs VERY infrequently, only when glucose or fatty acids are limited.
- Body breaks down tissue proteins to use the amino acids for glucose.
- Results in **muscle wasting.**
- Can happen during prolonged exercise when carbohydrates are not supplied throughout the exercise period.



KEY TAKEAWAYS

- ✓ Athletes require more daily protein than the RDA.
- ✓ Muscle protein turnover is the balance between breakdown and synthesis
- ✓ The 2 main drivers of MPS are protein and exercise.
- ✓ Leucine is the essential amino acid that drives MPS.
- ✓ All proteins are not created equal.
- ✓ Protein is not a primary source of fuel during exercise.

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