

Anabolic properties of proteins

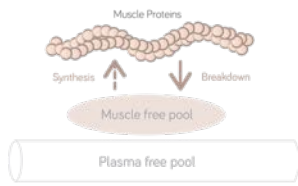
Prof. L.J.C. van Loon



Maastricht University Medical Centre+
Maastricht, the Netherlands
Danish Society for Clinical Nutrition
Copenhagen, May 12, 2023



Muscle protein turnover



Burd et al., *Exerc Sport Sci Rev*, 2013

Fractional muscle protein synthesis rates

1-2 % per day

(0.04 - 0.14 %·h⁻¹)



Muscle reconditioning



Lance Armstrong



Jay Cutler

Muscle deconditioning



- immobilisation
- sarcopenia
- cancer cachexia
- COPD
- type 2 diabetes
- cardiovascular disease

Muscle maintenance

Main anabolic stimuli

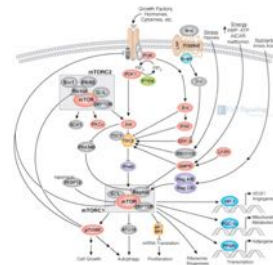
Nutrition is an anabolic stimulus



Amino acids



Amino acids stimulate protein synthesis



Post-prandial muscle protein synthesis

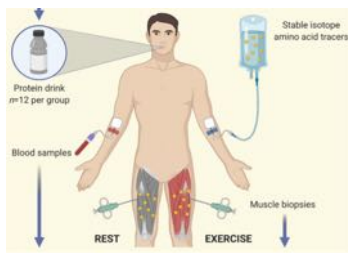
- protein digestion
- amino acid absorption
- plasma amino acid availability
- hormonal response
- postprandial perfusion
- muscle protein signaling proteins
- myofibrillar protein synthesis



Research methods



Stable isotope tracer infusion



Trommelen et al., Proc Nutr Soc, 2021

Post-prandial muscle protein synthesis

- protein digestion
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Stable isotope tracers



Intrinsically labeled protein



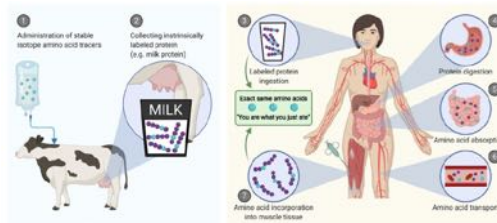
van Loon et al., J Dairy Sci, 2009; Penning et al., J Dairy Sci, 2010; Burd et al., PLOS One, 2013

Clinical nutrition studies



Green et al., PLOS one, 2015

Post-prandial protein handling



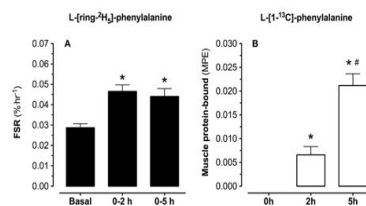
Trommelen et al., Proc Natl Acad Sci, 2021

Post-prandial protein synthesis



Green et al., PLOS one, 2015


Post-prandial protein synthesis



Green et al., PLOS one, 2015

'You are what you just ate'

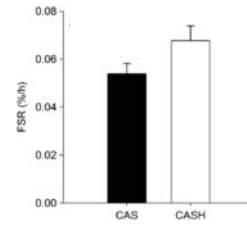
Post-prandial protein synthesis

-  - source of protein
-  - amount of protein
-  - macronutrients
-  - timing
-  - food preparation
-  - body position

Source of protein

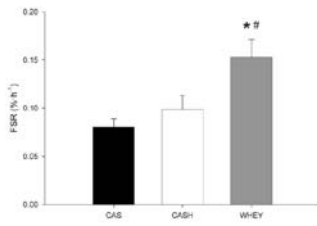


Intact protein versus protein hydrolysate



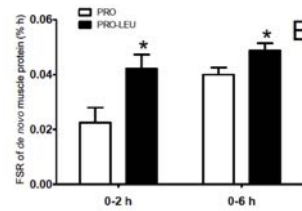
Koopman et al., Am J Clin Nutr, 2009

Whey versus casein



Penning et al., Am J Clin Nutr, 2011

Leucine co-ingestion



Wall et al., Clin Nutr, 2013

Whey versus casein



Milk versus Beef



Burd et al., Am J Clin Nutr, 2015

Plant-derived proteins: game changers?



Plant-based proteins

The Skeletal Muscle Anabolic Response to Plant- versus Animal-Based Protein Consumption¹

Stephan van Vliet,^{2,3} Nicholas A. Burd,^{2,3} and Luc J.C. van Loon^{1*}

¹Department of Kinesiology and Community Health, University of Illinois at Urbana-Champaign, Urbana, IL; and ²Department of Human Movement Sciences, Faculty of Health, Medicine, and Life Sciences, School for Nutrition and Translational Research in Metabolism (NUTRIM), Maastricht University, Maastricht, Netherlands

van Vliet et al., J. Nutr., 2015

Plant-based proteins



Muscle gain on plant-based protein consumption



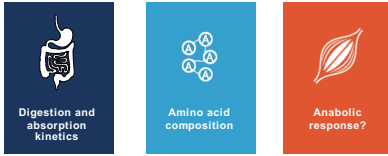
Muscle gain on plant-based protein consumption



Bill Pearl - 1971

Protein quality

Protein derived amino acid availability



Soy-derived protein



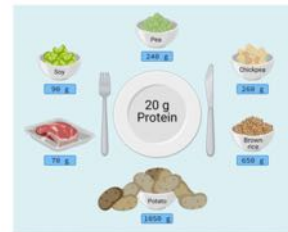
Tang et al., *J Appl Physiol*, 2009
Yang et al., *Nutr Metab*, 2012

Wheat-derived protein



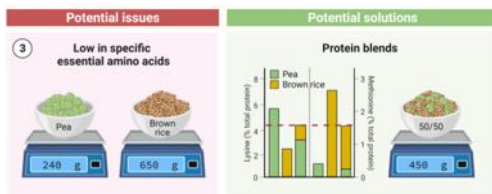
Groenen et al., *J Nutr*, 2016

Plant-based whole-foods



Poels et al., *Sports Med*, 2021

Anabolic properties of plant-based proteins



Poels et al., *Sports Med*, 2021

Insects and insect-derived proteins

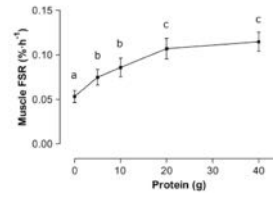


Churchward-Venne et al., *Nutr Rev*, 2017

Amount of dietary protein



Amount of dietary protein

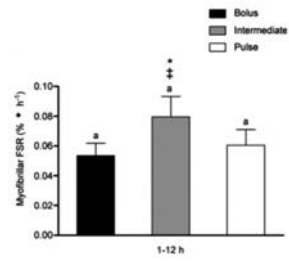


Moore et al., J Physiol, 2009

Timing of protein ingestion

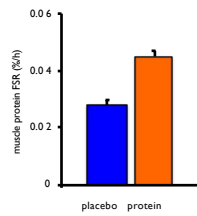


Protein intake distribution



Arora et al., J Physiol, 2011

Muscle protein synthesis during sleep



Groen et al., Am J Physiol, 2012

Food preparation



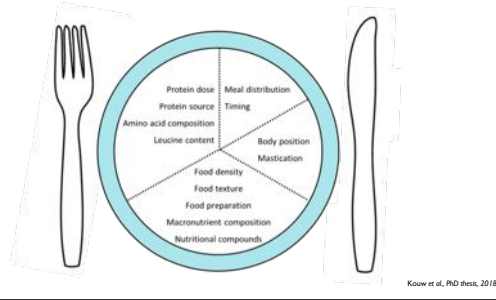
Body position



Whole-foods and food processing



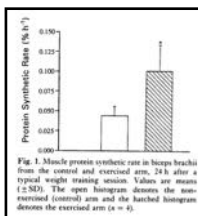
Post-prandial protein synthesis



Muscle contraction is an anabolic stimulus

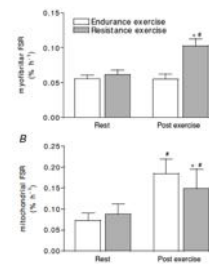


Muscle contraction



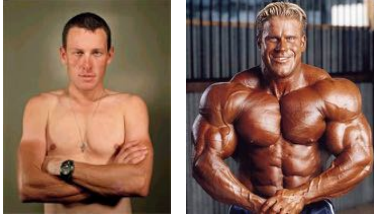
Chesley et al., J Appl Physiol, 1992

Post-exercise muscle protein synthesis



Wilkinson et al., J Physiol, 2008

Muscle reconditioning

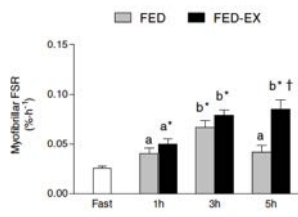


Lance Armstrong

Jay Cutler

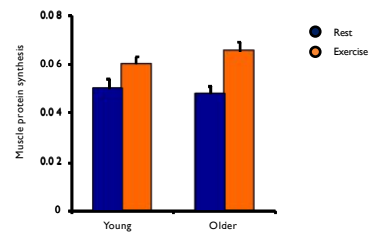
Synergy between exercise and food intake

Exercise and nutrition



Moore et al., J Physiol, 2009

Post-prandial muscle protein synthesis



Pennings et al., Am J Clin Nutr, 2010

Physical activity prior to food intake

'You are more of what you just ate'

Sports nutrition



Clinical nutrition



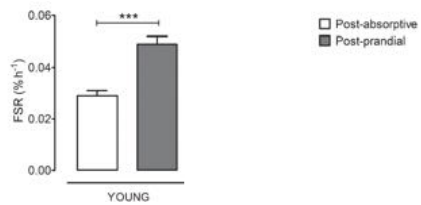
Muscle deconditioning



- sarcopenia
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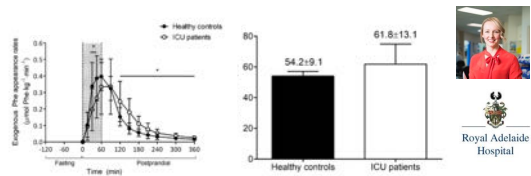
What causes muscle loss with aging

Anabolic resistance



Wall et al., PLOS one, 2015

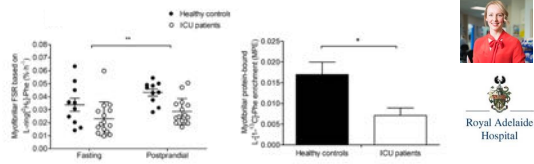
Anabolic resistance in the ICU



Royal Adelaide Hospital

Chapple et al., Am J Respir Crit Care Med, 2022

Anabolic resistance in the ICU



Royal Adelaide Hospital

Chapple et al., Am J Respir Crit Care Med, 2022

Concept of anabolic resistance

Burd et al., J Appl Physiol, 2012

Physiological factors

- Protein digestion
- Amino acid absorption
- Postprandial hormonal response
- Microvascular perfusion
- Amino acid uptake in muscle
- Intramuscular signalling
- Muscle protein synthesis

Anabolic resistance of muscle protein synthesis

- Lower level of physical activity
- Changes in food intake
- Bedrest
- Hospitalization
- Insulin resistance
- Obesity
- Aging
- Inflammation
- Health status
- Medication

Clinical factors

Kouw et al., PhD thesis, 2018

Decline in physical activity

Burd et al., J Appl Physiol, 2012

Muscle disuse

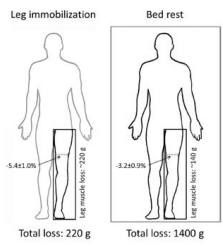


Wall et al., Acta Physiol Scand, 2013

Muscle deconditioning



Muscle mass loss during disuse

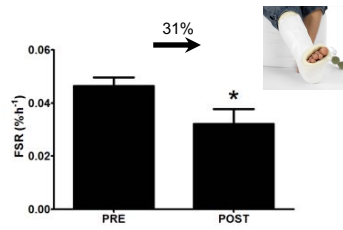


Dirks et al., *J Appl Physiol*, 2017



Dirks et al., *Diabetes*, 2016

Anabolic resistance to protein ingestion



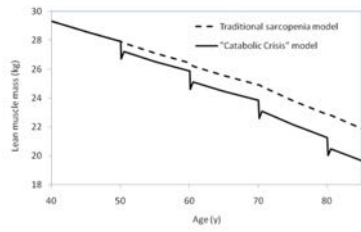
Wall et al., *J Clin Endocrinol Metab*, 2011

Decline in physical activity

'You are less of what you just ate'

Clinical relevance

Catabolic crisis model



English et al., Curr Opin Clin Nutr Metab Care, 2010

Hospital admission

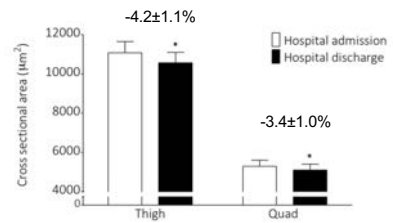


Short periods of bedrest following disease or injury contribute substantially to the loss of muscle mass with aging

Wall et al., Aging Res Rev, 2013



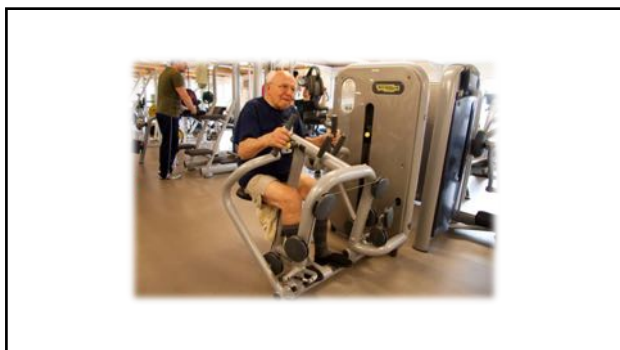
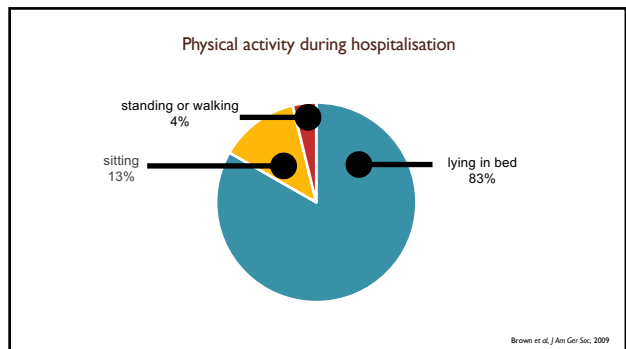
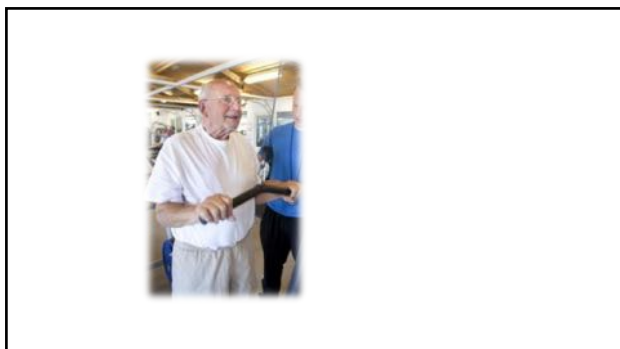
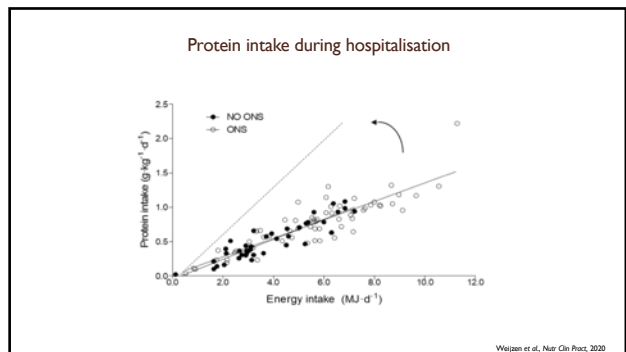
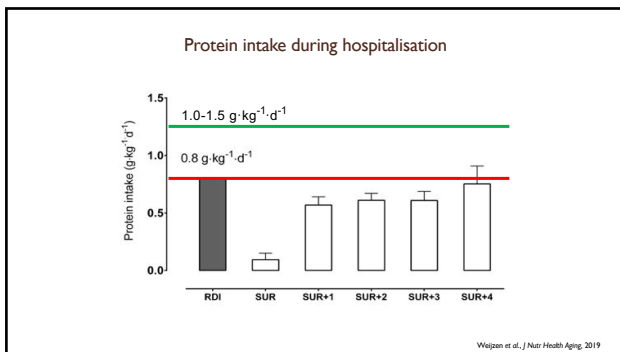
Muscle loss during hospitalisation



Koov et al., JAMA, 2018

Attenuate muscle mass and/or strength loss





Conclusions

- Protein ingestion and muscle contraction stimulate muscle tissue protein synthesis
- Physical (in)activity (de)sensitizes skeletal muscle tissue to the anabolic properties of dietary protein ingestion
- Protein is required to support muscle conditioning in both health and disease

Attenuate muscle loss during disuse

- Remain physically active as much as possible
- Apply exercise mimetics when appropriate
- Consume a more protein dense diet
- Commit to an active rehabilitation program

Collaborators and sponsors

