

Muscle mass maintenance in older people

Prof. L.J.C. van Loon



Maastricht University Medical Centre+
Maastricht, the Netherlands



Belfast, April 16, 2019



Protein and physical activity

Prof. L.J.C. van Loon



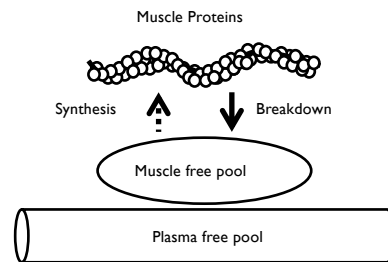
Maastricht University Medical Centre+
Maastricht, the Netherlands



Belfast, April 16, 2019



Muscle protein turnover



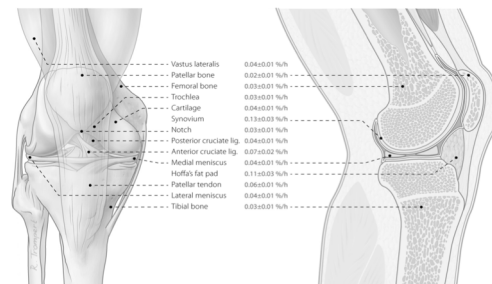
Burd et al., Exerc Sport Sci Rev, 2013

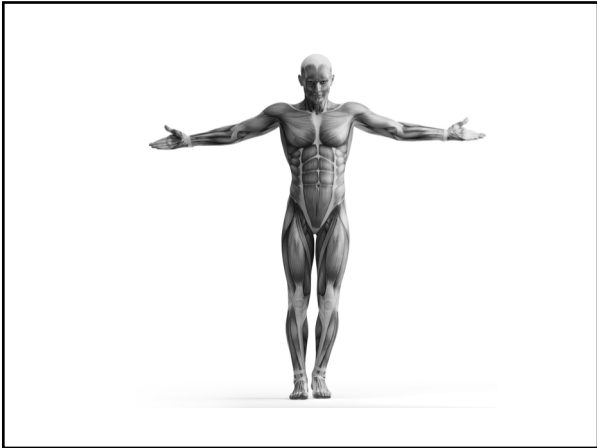
Fractional muscle protein synthesis

1-2 % per day

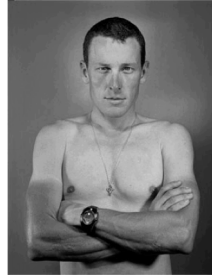
(0.04 – 0.14 %·h⁻¹)

Bone, cartilage and ligaments





Muscle reconditioning



Lance Armstrong



Jay Cutler

Muscle deconditioning

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

Muscle maintenance

Main anabolic stimuli

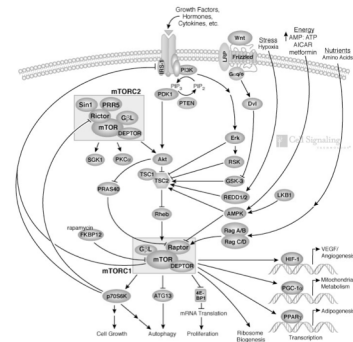
Nutrition is an anabolic stimulus



Amino acids

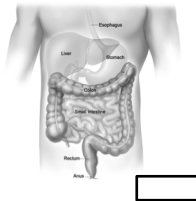


Amino acids stimulate protein synthesis

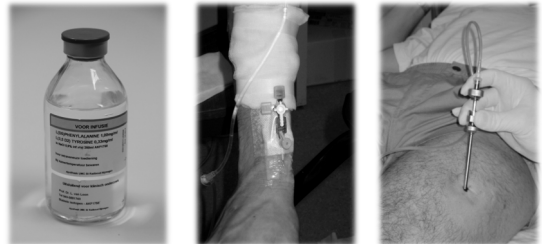


Post-prandial muscle protein synthesis

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

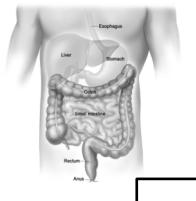


Research methods



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



Stable isotope tracers



Intrinsically labeled protein



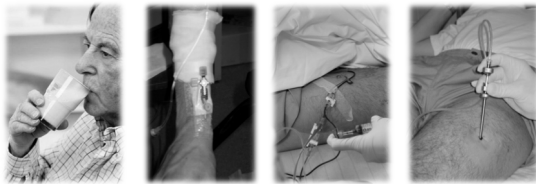
van Loon et al., *J Dairy Sci*, 2009, Penning et al., *J Dairy Sci*, 2010, Burd et al., *PLoS One*, 2013

Post-prandial protein synthesis



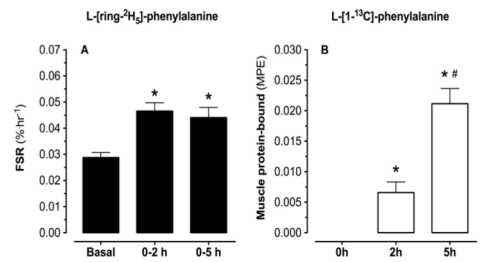
Groen et al., *PLoS one*, 2015

Post-prandial protein synthesis



Groen et al., *PLoS one*, 2015



Post-prandial protein synthesis



Groen et al., *PLoS one*, 2015

'You are what you just ate'

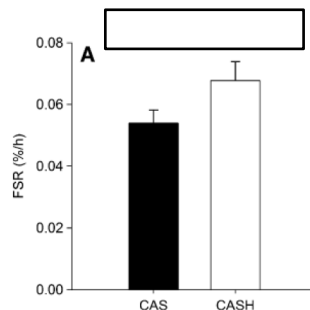
Post-prandial protein synthesis

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

Source of protein

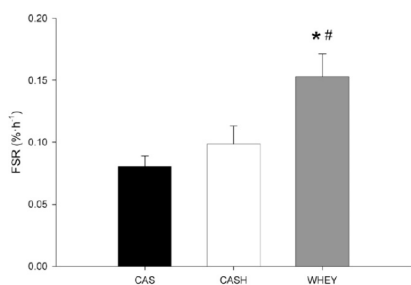


Intact protein versus protein hydrolysate



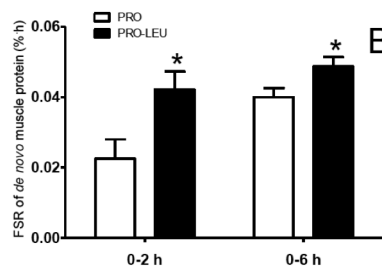
Koopman et al., *Am J Clin Nutr*, 2009

Whey versus casein



Penninga et al., *Am J Clin Nutr*, 2011

Leucine co-ingestion



Wai et al., *Clin Nutrition*, 2013

Milk versus Beef



Burd et al., *Am J Clin Nutr*, 2015

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^{3*}

²Department of Kinesiology and Community Health, University of Illinois at Urbana-Champaign, Urbana, IL; and ³Department of Human Movement Sciences, Faculty of Health, Medicine, and Life Sciences, School for Nutrition and Translational Research in Metabolism (NUTRIM), Maastricht University, Maastricht, Netherlands

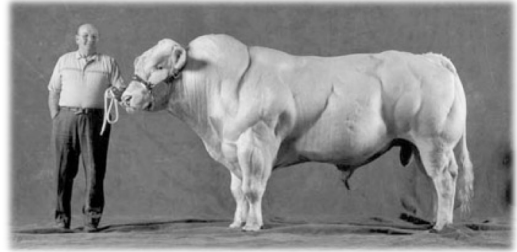
van Vliet et al., *J Nutr*, 2015

Plant based proteins



van Vliet et al., J Nutr, 2015

Muscle gain on plant based protein consumption



Soy



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

Wheat



Gorissen et al., J Nutr, 2016

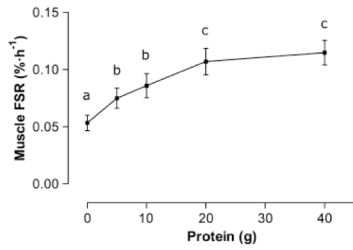
Meals



Amount of dietary protein



Amount of dietary protein



Moore et al., J.Physiol, 2009

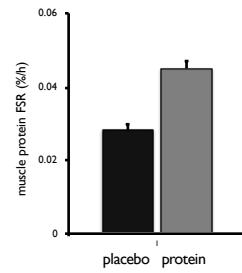
Other macronutrients



Timing of protein ingestion



Muscle protein synthesis during sleep



Groen et al., Am J Physiol, 2012

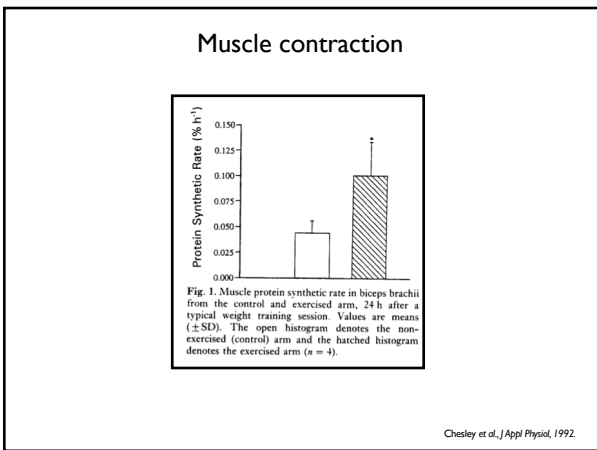
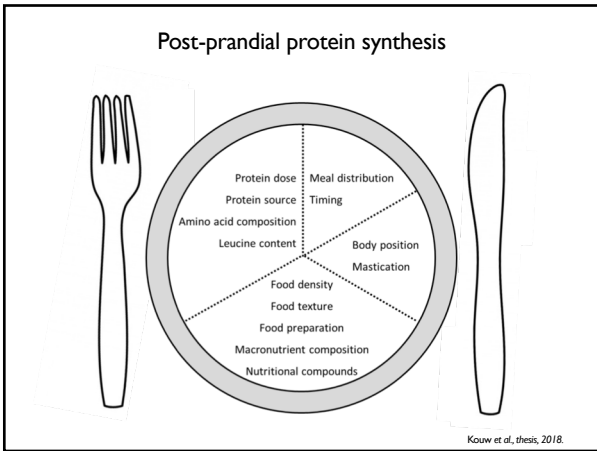
Food preparation



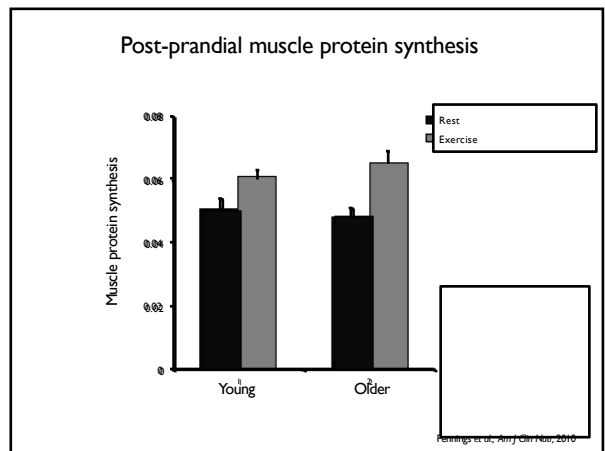
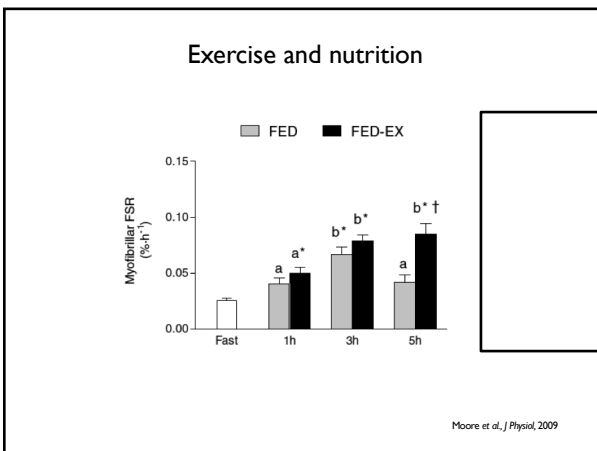
Body position



Holwerda et al., Appl Physiol Nutr Metab, 2017



Physical activity and food intake



Physical activity prior to food intake

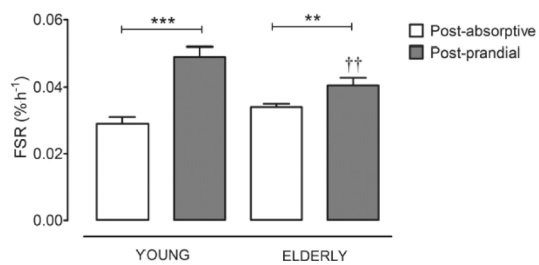
'You are more of what you just ate'

Muscle deconditioning

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

What causes muscle loss with aging

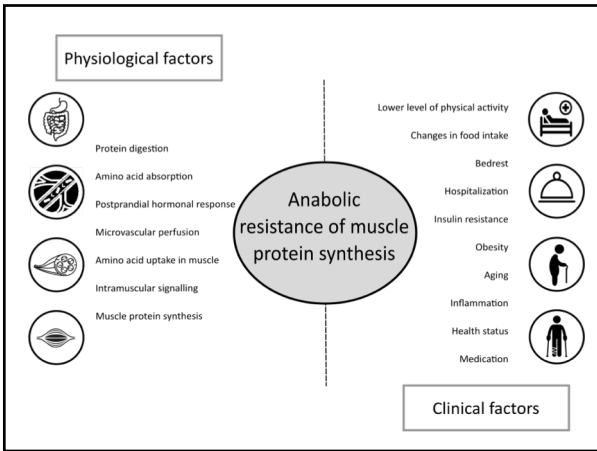
Anabolic resistance



Wall et al., PLOS one, 2015

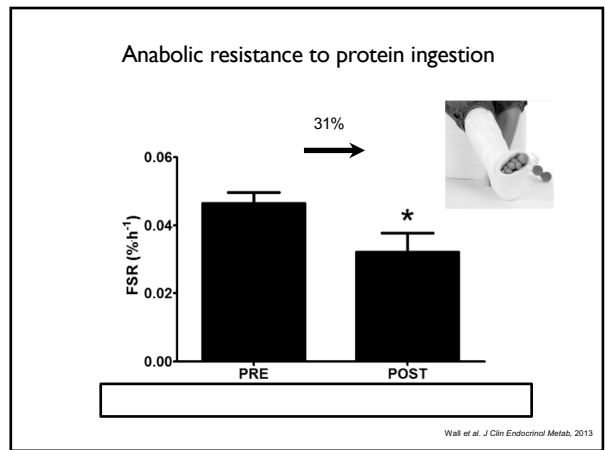
Concept of anabolic resistance

Burd et al., J Appl Physiol, 2012



Decline in physical activity

Burd et al., J Appl Physiol, 2012



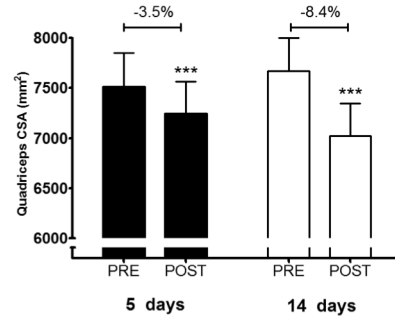
Decline in physical activity

'You are less of what you just ate'

Muscle deconditioning

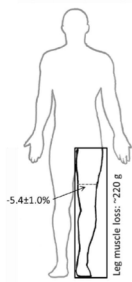


Short term muscle disuse



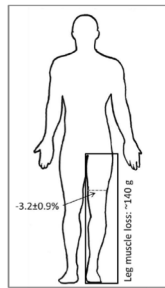
Wall et al. *Acta Physiol. Scand.*, 2013

Leg immobilization



Total loss: 220 g

Bed rest



Total loss: 1400 g

Dirks et al. *J Appl Physiol* 2017

Marlou L. Dirks,¹ Benjamin T. Wall,¹ Bas van de Valk,¹ Tanya M. Holloway,²
Graham P. Holloway,² Adrian Chabowski,³ Gijs H. Goossens,¹ and Luc J.C. van Loon¹

One Week of Bed Rest Leads to Substantial Muscle Atrophy and Induces Whole-Body Insulin Resistance in the Absence of Skeletal Muscle Lipid Accumulation

Diabetes 2016;65:2862-2875 | DOI: 10.2337/db15-1661



Dirks et al. *Diabetes*, 2016

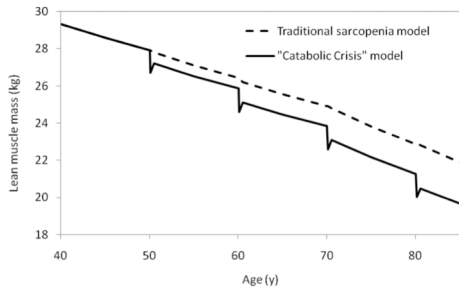
Hospital admission



Most older patients are typically hospitalized for 5-7 days

Fisher et al. *Arch Intern Med.* 2010

Catabolic crisis model



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

Hospital admission

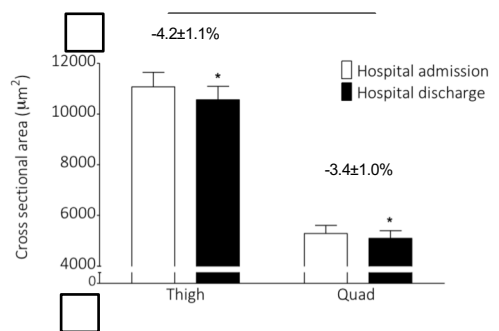


Short periods of bedrest following disease or injury contribute substantially to the loss of muscle mass with aging

Wall et al., *Aging Res. Rev.*, 2013



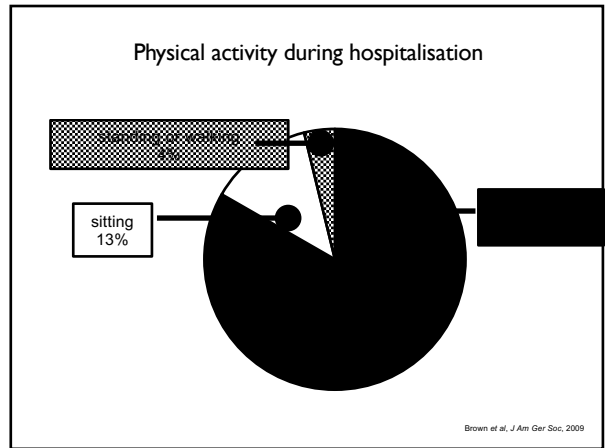
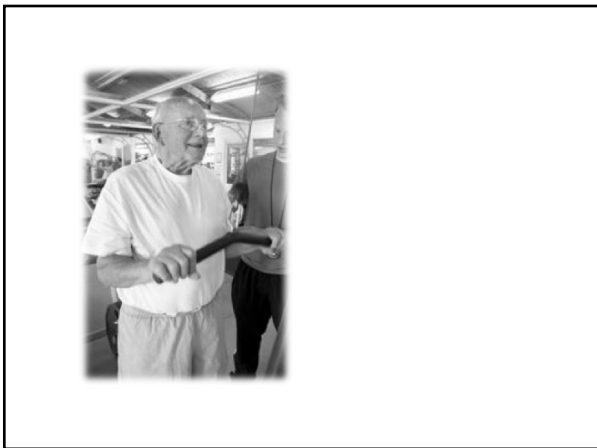
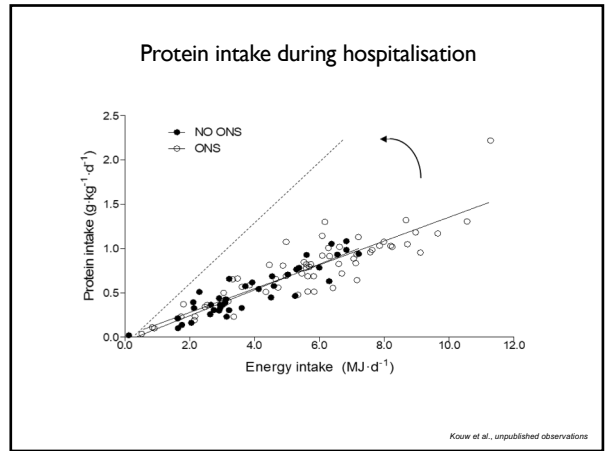
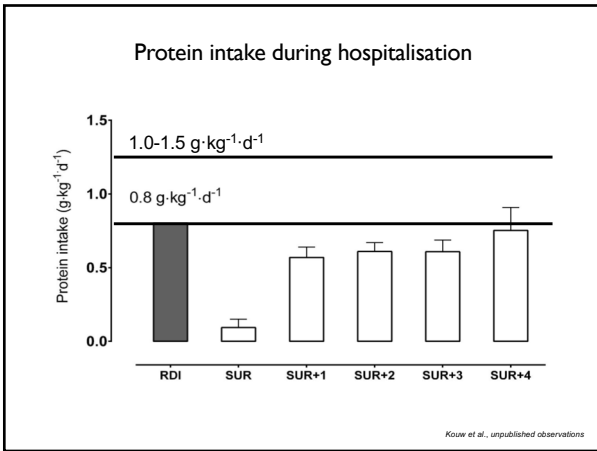
Muscle loss during hospitalisation



Kozov et al., *JAMDA*, 2018

Attenuate muscle mass and/or strength loss





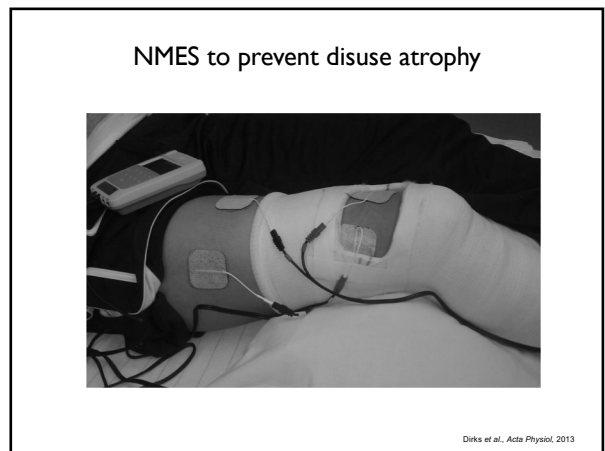
Bed rest and physical activity

Unique Bed Loom Gives Invalids Fun and Exercise

KEEPING young patients entertained while exercising their muscles at the same time is the purpose of the invalid's weaving loom pictured at the left. The invention of Margaret Gleave, a nurse at the James Whitcomb Riley Hospital for Children, in Indianapolis, Ind., the loom is operated by youngsters suffering from leg and hip diseases to help them exercise their afflicted limbs. The invention won a fifty-dollar prize for the nurse.

Taking this kind of medicine is fun—and good for the patient, too

*Akima, Acta Physiol Scand, 2001
Oates et al. Muscle Nerve, 2010*



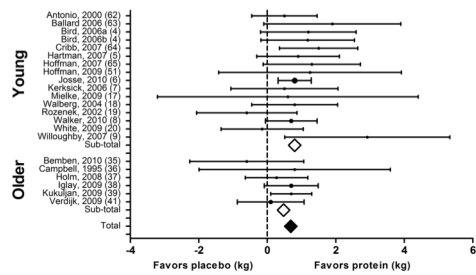
Comatose patients



Rehabilitation

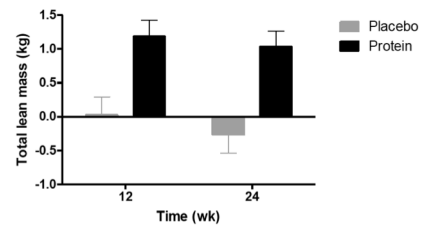


Exercise training and protein supplementation



Cermak et al., Am J Clin Nutr, 2012.

Protein supplementation in frail elderly



Treland et al., JAMDA, 2012-8

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

Protein intake distribution

Collaborators and sponsors

