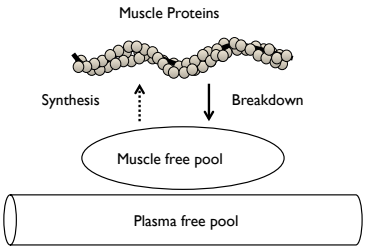
Dietary protein and muscle conditioning

Prof. L.J.C. van Loon

Maastricht University Medical Centre+
Maastricht, the Netherlands

Aarhus, December 13, 2016

Muscle protein synthesis



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

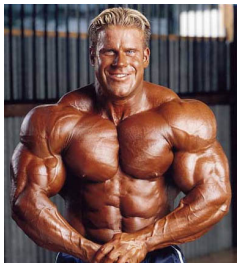
Fractional muscle protein synthesis

1-2 % per day

(0.04 – 0.14 %·h^{-1})

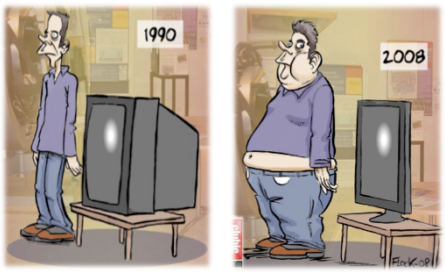
Muscle reconditioning

Lance Armstrong

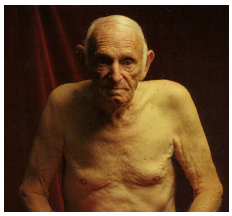


Jay Cutler

Lifestyle changes



Muscle deconditioning



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

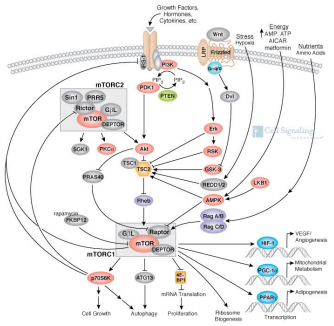
What regulates muscle maintenance?

Main anabolic stimuli

Nutrition is an anabolic stimulus

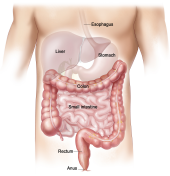
Amino acids

Amino acids stimulate protein synthesis

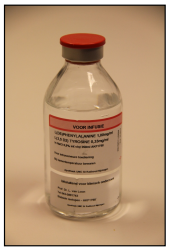


Post-prandial muscle protein synthesis

- 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

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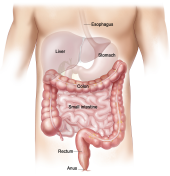


Intrinsically labeled protein

Intrinsically labeled protein

van Loon *et al., J Dairy Sci*, 2009, Pennings *et al., J Dairy Sci*, 2010, Burd *et al., PLoS ONE*, 2013

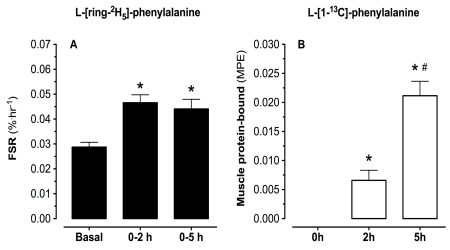
Post-prandial protein synthesis

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'

PLOS ONE

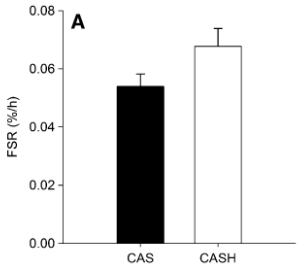
RESEARCH ARTICLE

Post-Prandial Protein Handling: You Are What You Just Ate

Bart B. L. Groen[1,2], Astrid M. Horstman[1,2], Henrike M. Hamer[1,2], Michiel de Haan[3], Janneau van Kranenburg[3], Jörgen Bierau[4], Martijn Poeze[5], Will K. W. H. Wodzig[6], Blake B. Rasmussen[7], Luc J. C. van Loon[1,2]*

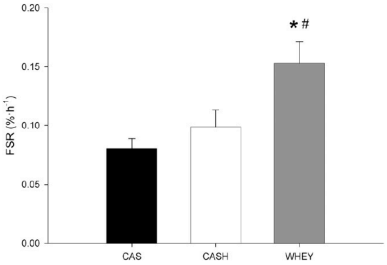
Groen *et al., PLoS ONE*, 2015

Intact protein versus protein hydrolysate



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

Whey versus casein



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

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 Consumption[1]

Stephan van Vliet,[2,3] Nicholas A Burd,[2,3] and Luc JC van Loon[3]*

[2]Department of Kinesiology and Community Health, University of Illinois at Urbana-Champaign, Urbana, IL; and [3]Department 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

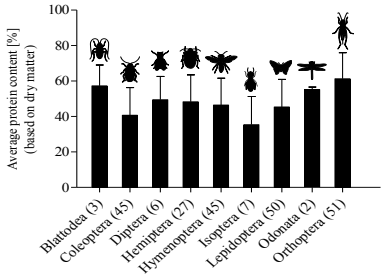
Wheat

Gorissen et al., J Nutr, 2016

Alternative protein sources

Churchward-Venne *et al., unpublished*

Insect proteins

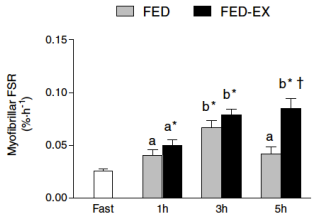


Churchward-Venne *et al., unpublished*

Muscle contraction is an anabolic stimulus

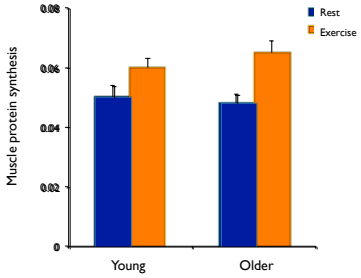
Synergy between exercise and food intake

Exercise and nutrition



Moore *et al., J Physiol*, 2009

Post-prandial muscle protein synthesis

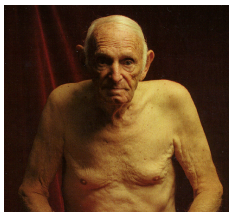


Pennings *et al., Am J Clin Nutr*, 2010

Physical activity prior to food intake

'You are more of what you just ate'

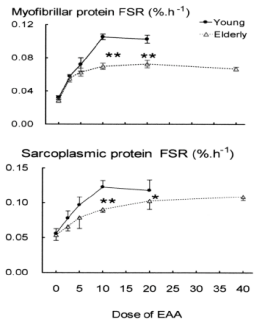
Muscle deconditioning



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

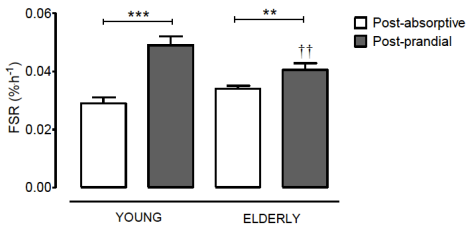
What causes muscle loss with aging

Anabolic resistance



Cuthbertson *et al., FASEB J.*, 2005

Anabolic resistance



Wall *et al., PLoS ONE, 2015*

Concept of anabolic resistance

J Appl Physiol 112: 1233–1235, 2012;
doi:10.1152/japplphysiol.01343.2011.

Perspectives

VIEWPOINT

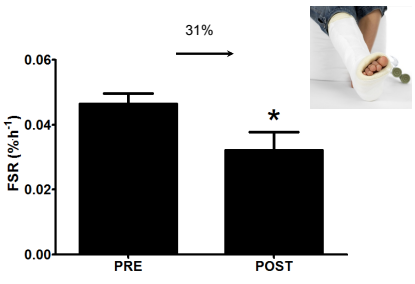
The curious case of anabolic resistance: old wives' tales or new fables?

Nicholas A. Burd, Benjamin T. Wall, and Luc J. C. van Loon
Department of Human Movement Sciences, NUTRIM School for Nutrition, Toxicology and Metabolism, Maastricht University Medical Centre+ (MUMC+), Maastricht, The Netherlands

Burd *et al., J Appl Physiol.*, 2012

Decline in physical activity

Anabolic resistance to protein ingestion



Wall *et al. J Clin Endocrinol Metab*, 2013

‘You are less of what you just ate’

Clinical relevance

Exercise training in the elderly

Muscle mass and strength

Endurance capacity

Functional capacity

Frontera et al., 1988, 1990, 2003, Fiatarone et al., 1990, 1994, Charette et al., 1991, Lexell et al., 1995, Ades et al., 1996, Vincent et al., 2002, Borreman et al., 2003, Brose et al., 2003, Ferri et al., 2003, Roth et al., 2003, Short et al., 2003, 2004, Verdijk et al., 2009

ELSEVIER

JAMDA

journal homepage: www.jamda.com

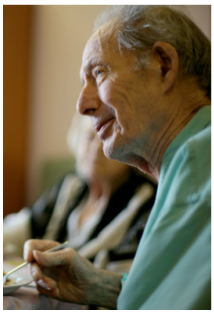
Original Study

There Are No Nonresponders to Resistance-Type Exercise Training in Older Men and Women

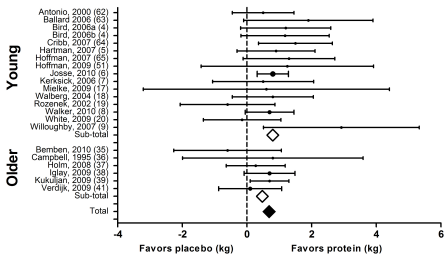
Tyler A. Churchward-Venne PhD [a,b], Michael Tieland PhD [b,c], Lex B. Verdijk PhD [a,b], Marika Leenders MSc [a,b], Marlou L. Dirks MSc [a], Lisette C.P.G.M. de Groot PhD [b,c], Luc J.C. van Loon PhD [a,b,*]

[a] *Department of Human Movement Sciences, NUTRIM School for Nutrition, Toxicology and Metabolism, Maastricht University Medical Centre+, Maastricht, The Netherlands*
[b] *Top Institute Food and Nutrition, Wageningen, The Netherlands*
[c] *Division of Human Nutrition, Wageningen University, Wageningen, The Netherlands*

Churchward-Venne et al., JAMDA, 2015

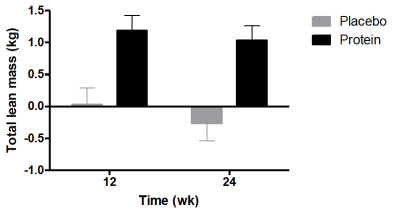


Exercise training and protein supplementation



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

Protein supplementation in frail elderly

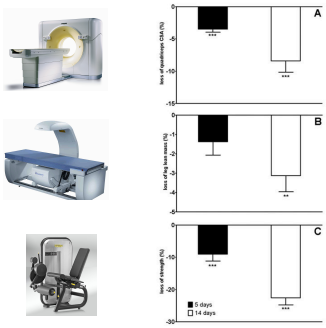


Tieland *et al., JAMDA, 2012-8*

Muscle disuse atrophy

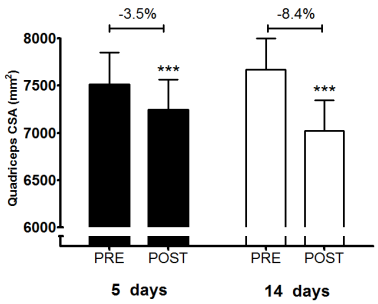
Wall *et al. Acta Physiol. Scand.*, 2013

Short term muscle disuse atrophy



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

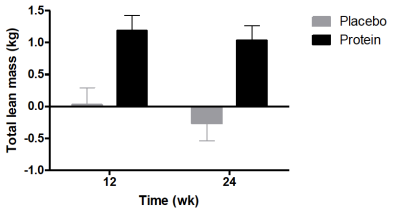
Short term muscle disuse



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

Bedrest and disuse atrophy

Protein supplementation in frail elderly



Tieland *et al., JAMDA, 2012-8*

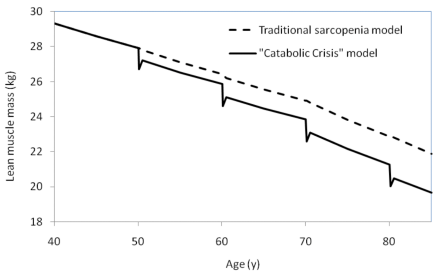
Bedrest and disuse atrophy

Hospital admission

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

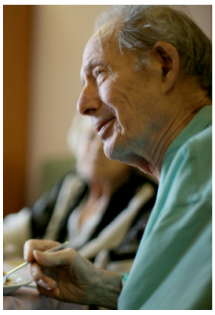
Wall *et al., Aging Res. Rev.*, 2013

Catabolic crisis model



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

Attenuating muscle disuse atrophy

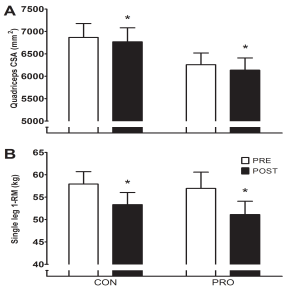


Maintaining energy balance

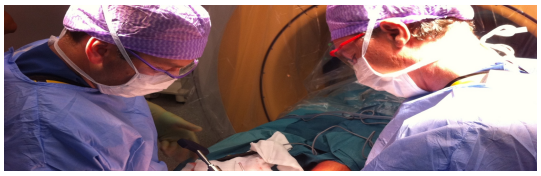
Negative energy balance: 3 fold greater loss of muscle tissue during disuse

Biolo et al. *Am J Clin Nutr*, 2007

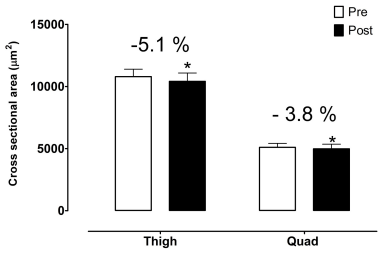
Protein supplementation during short term disuse



Dirks et al., *J. Nutr.*, 2014

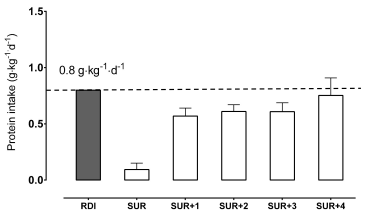


Muscle loss during hospitalisation



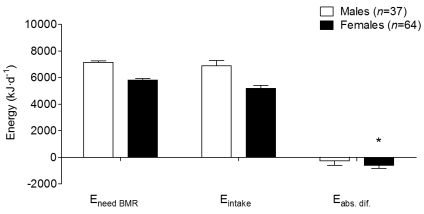
Kouw et al., *unpublished observations*

Protein intake during hospitalisation



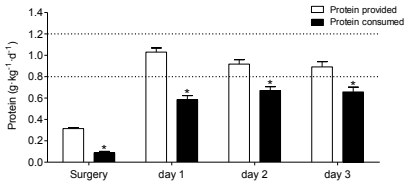
Kouw et al., *unpublished observations*

Energy intake during hospitalisation



Weijzen et al., *unpublished observations*

Protein intake during hospitalisation



Weijzen et al., unpublished observations

Nutritional support

Post-prandial muscle protein synthesis

- amount of dietary protein

- type of protein

-timing of protein ingestion

Nutritional compounds

- Leucine
- Creatine
- EAA/BCAA
- Resveratrol
- Ursolic acid
- HMB
- Trigonelline
- Vitamin D
- Omega-3 fatty acids

Bed rest and physical activity

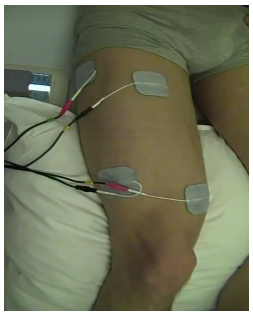
Unique Bed Loom Gives Invalids Fun and Exercise

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

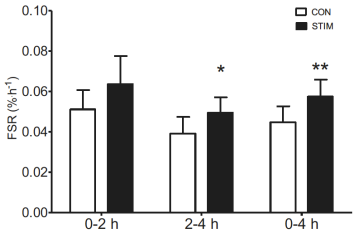
Akima, *Acta Physiol Scand*, 2001
Oates *et al. Muscle Nerve*, 2010

Neuromuscular electrical stimulation



Wall *et al., Nutr Rev,* 2013

Neuromuscular electrical stimulation

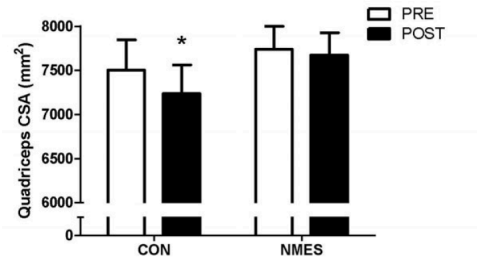


Wall *et al. Am J Physiol,* 2012

NMES to prevent disuse atrophy

Dirks *et al., Acta Physiol,* 2013

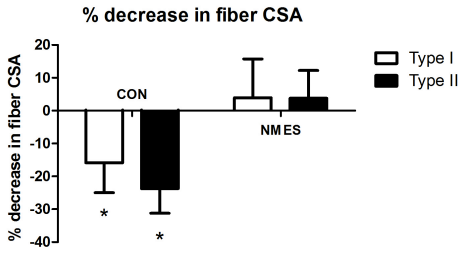
NMES to prevent disuse atrophy



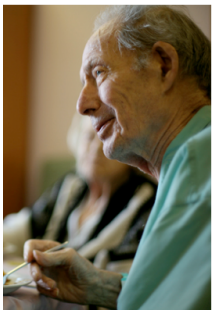
Dirks *et al., Acta Physiol,* 2013

Comatose patients

NMES during coma



Dirks *et al., unpublished*

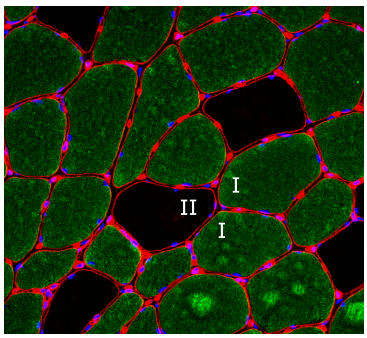
NMES and nutritional intervention

Combining NMES with pre-sleep protein ingestion increases the overnight muscle protein synthetic response

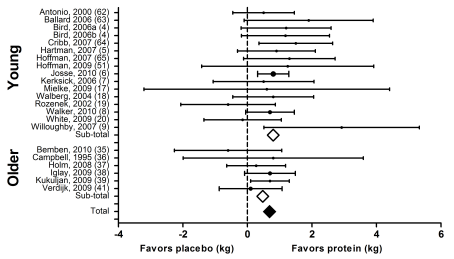
Dirks et al., *unpublished observations*

Preserving muscle mass

Preserving muscle strength

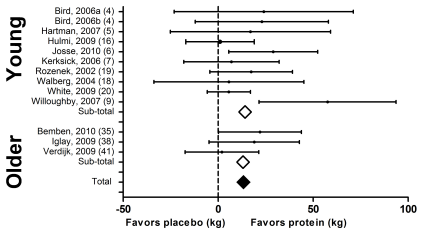


Exercise training and protein supplementation



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

Exercise training and protein supplementation



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

Post-exercise muscle protein synthesis

- amount of dietary protein

- type of protein

-timing of protein ingestion

Conclusions

Protein ingestion and muscle contraction stimulate muscle protein synthesis

Physical (in)activity (de)sensitizes skeletal muscle tissue to the anabolic properties of dietary protein ingestion

Short term disuse induces anabolic resistance and strongly reduces muscle mass and strength

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

Regain muscle mass and strength following disuse

Rehabilitate to regain muscle and strength losses
Choose exercise to allow type II fiber recruitment
Consume protein after each (rehabilitative) exercise session
Protein intake distribution

Collaborators and sponsors