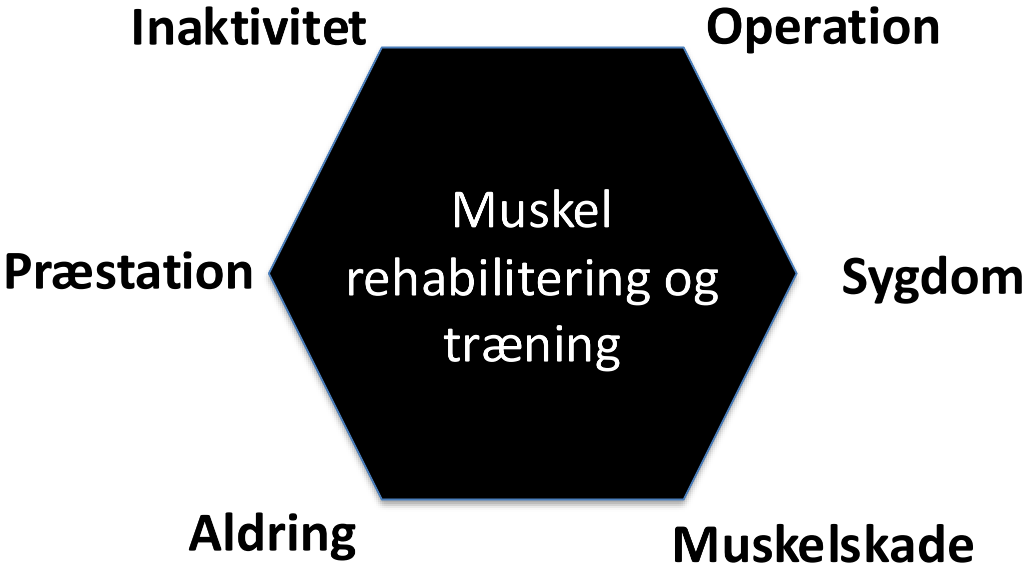
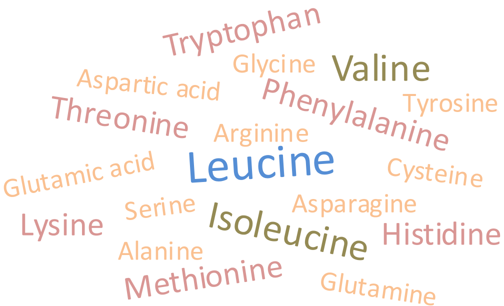
Ernæringsmæssige overvejelser ved muskelrehabilitering

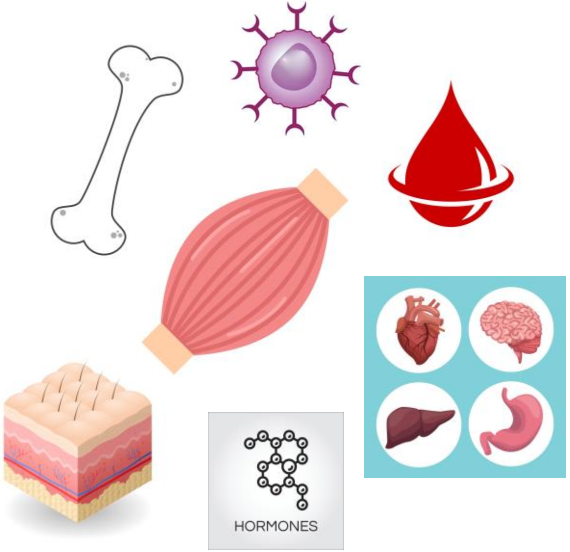
Senior Researcher, Jakob Agergaard
Institute of Sports Medicine Copenhagen

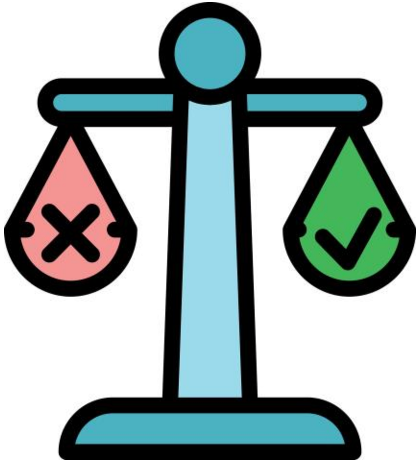


Øge muskelmasse og styrke for at forbedre musklens kvalitet og funktion

Hvorfor protein?







Muskel protein nedbrydning

- Sygdom
- Inaktivitet
- Inflammation
- Stress hormoner
- .....

Muskel protein syntese

- Træning
- Hormoner
- Protein indtag
- .....

Effekt af proteinindtag på muskelmasse og styrke

Effekt at proteinindtag på muskelmasse

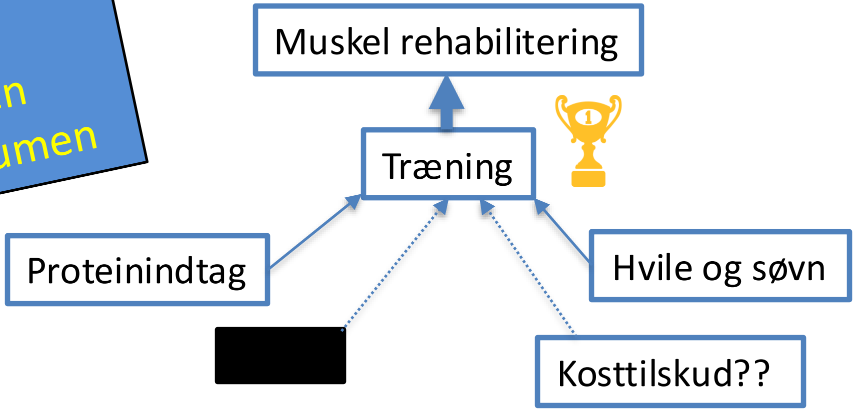
Groups/subgroups	SMD	95% CI	Number of trials/ intervention groups	*P*-value	I^2 (%)
All RCT	0.22	0.15:0.29	66/93	<0.01	7
RCT without resistance exercise	0.21	-0.15:0.58	6/6	0.38	25
RCT with resistance exercise (RE)	0.22	0.14:0.30	62/87	<0.01	6.2

Effekt at proteinindtag på muskelstyrke

Groups/subgroups	SMD	95% CI	Number of trials/ intervention groups	*P*-value	I^2 (%)
All RCT reporting lower-body strength	0.20	0.08:0.33	50/70	<0.01	52.8
RCT without resistance exercise	0.14	−0.36:0.64	4/4	0.44	20.4
RCT with resistance exercise (RE)	0.21	0.08:0.34	47/66	<0.01	54.5

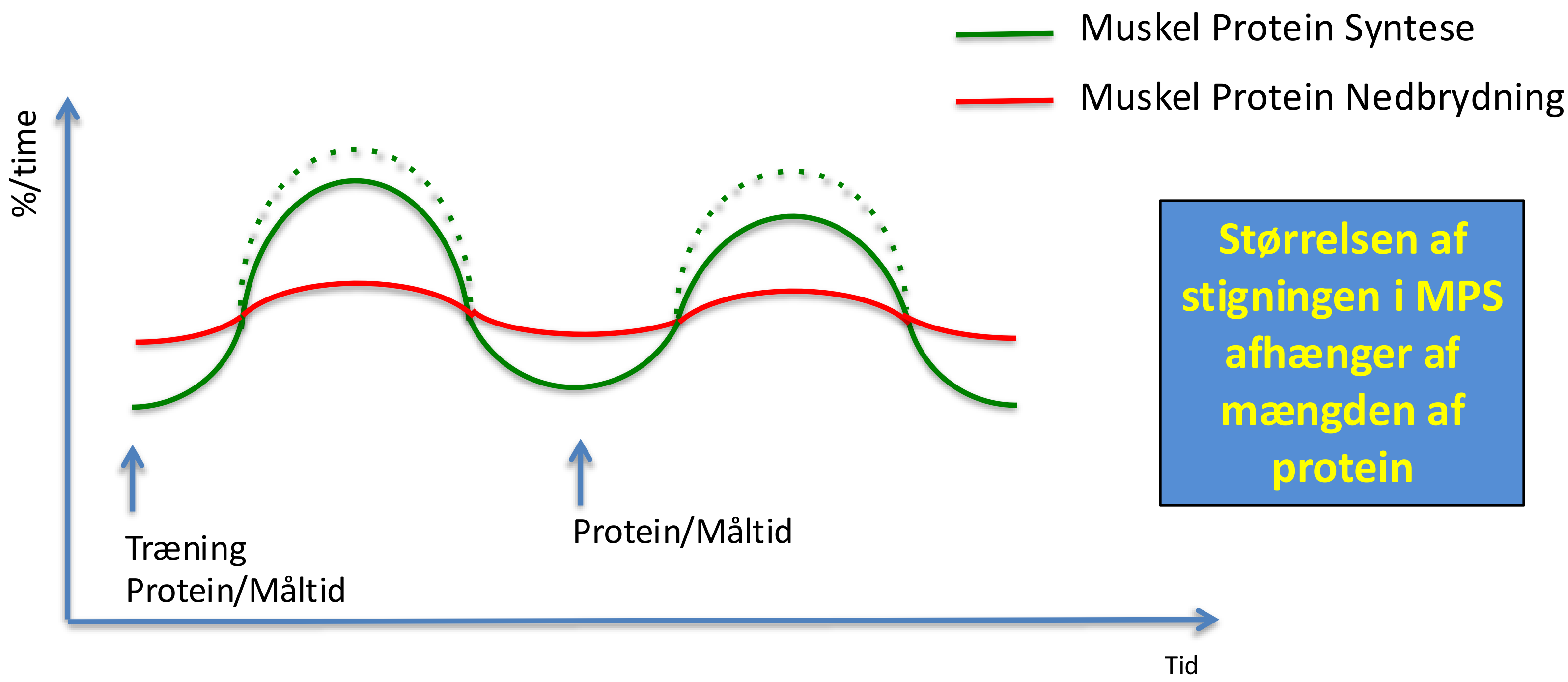
Øge muskel masse og styrke for at forbedre musklens kvalitet og funktion

- Størrelsen af muskelmassen
- Træningsvolumen



Nunes et al. 2022 J Cachexia Sarcopenia Muscle

Protein balance

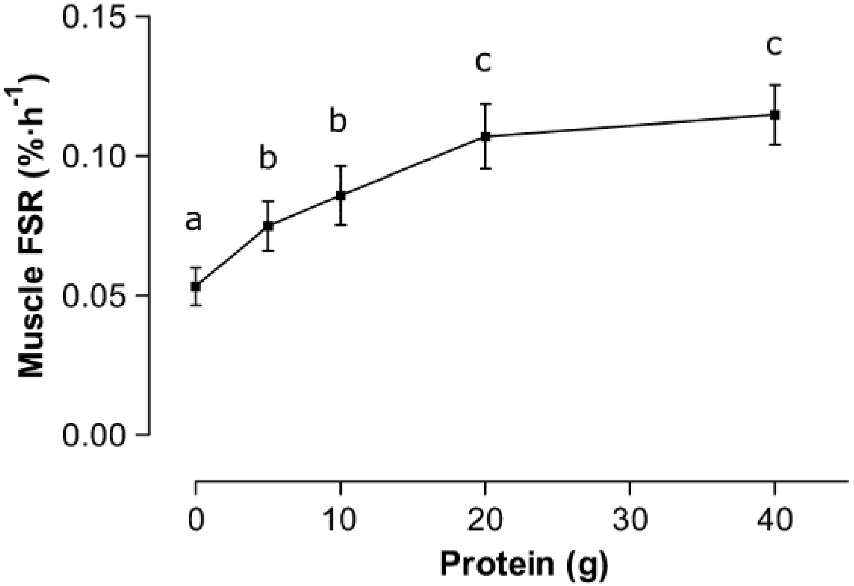


Størrelsen af stigningen i MPS afhænger af mængden af protein

Hvor meget protein har man behov for?

Protein tærskel

Raske mænd (n=6, alder 26 ± 3 år)
Tung styrketræning før protein indtag



Moore et al 2009, Am J Clin Nutr

42 studiearme, 723 deltagere

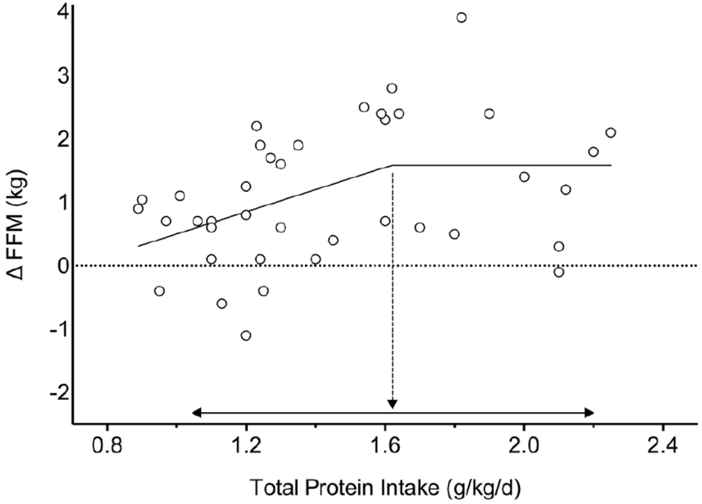
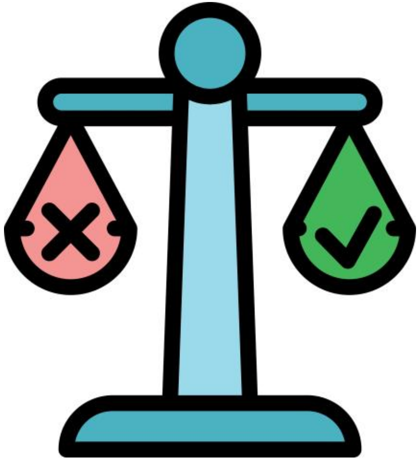


Figure 5 Segmental linear regression between relative total protein intake (g/kg body mass/day) and the change in fat-free mass (ΔFFM) measured by dual energy X-ray absorptiometry. Each circle represents a single group from a study. Dashed arrow indicates the break point=1.62 g protein/kg/day, p=0.079. Solid arrow indicates 95% CI, (1.03 to 2.20).

Morton et al 2018, Br J Sports Med

Guidelines for dagligt protein indtag?

1) WHO: RDA = 0.83 g protein/kg kropsvægt
    - For at sikre protein-balance



Guidelines for dagligt protein indtag?

1) WHO: RDA = 0.83 g protein/kg kropsvægt
   - For at sikre protein-balance

2) NNR: >65 år: 1.2 g protein/kg kropsvægt
   - Immunfunktion
   - Restitution efter sygdom
   - Vævsheling
   - Bibeholde muskelmasse

Guidelines for dagligt protein indtag?

1) WHO: RDA = 0.83 g protein/kg kropsvægt
   - For at sikre protein-balance

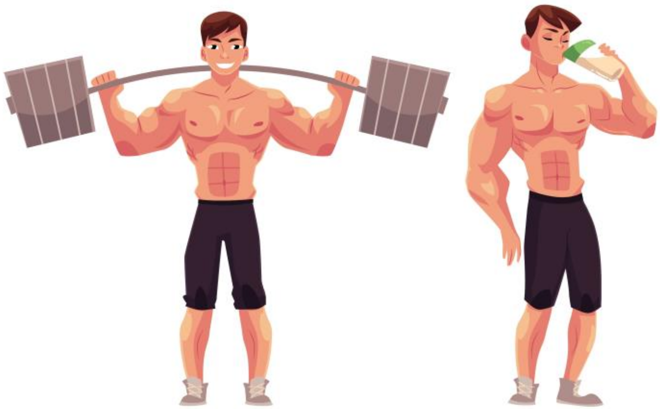
2) NNR: >65 år: 1.2 g protein/kg kropsvægt
   - Immunfunktion
   - Restitution efter sygdom
   - Vævsheling
   - Bibeholde muskelmasse

3) ACSM: Atleter: 1.6 (1.2-2.0) g protein/kg kropsvægt
   - For at understøtte:
     - Metabolisk tilpasninger
     - Vævs reperation og remodelering
     - Protein omsætning

75 kg x 1.6 g protein = 120 g protein

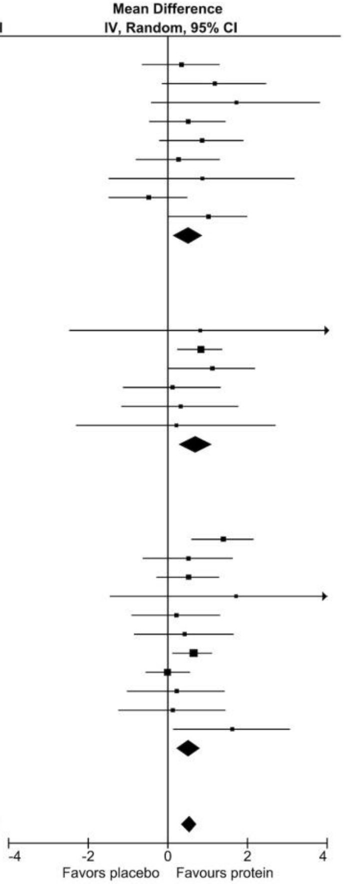
Myter om proteinindtag

Du skal indtage protein umiddelbart efter en træning



Timing af indtag

Study or Subgroup	Weight	Mean Difference IV, Random, 95% CI
After exercise		
Holm 2008 (26)	3.9%	0.33 [-0.64, 1.29]
Hwang 2017 (49)	2.1%	1.16 [-0.14, 2.46]
Negro 2014 (53)	0.8%	1.70 [-0.41, 3.81]
Pihoker 2019 - after EX (55)	4.0%	0.49 [-0.46, 1.44]
Reidy 2016 - soy (56)	3.3%	0.84 [-0.21, 1.89]
Reidy 2016 - whey (56)	3.3%	0.25 [-0.79, 1.29]
Villanueva 2014 (77)	0.7%	0.85 [-1.47, 3.17]
Volek 2013 - soy (63)	3.8%	-0.50 [-1.48, 0.48]
Volek 2013 - whey (63)	3.8%	1.00 [0.02, 1.98]
Subtotal (95% CI)	**25.7%**	**0.51 [0.13, 0.89]**
Heterogeneity: Tau² = 0.00; Chi² = 8.12, df = 8 (P = 0.42); I² = 1%		
Test for overall effect: Z = 2.66 (P = 0.008)		
Before exercise and after exercise		
Hoffman 2009 - before and after EX (19)	0.3%	0.80 [-2.46, 4.06]
Josse 2010 (50)	11.8%	0.80 [0.25, 1.35]
Taylor 2015 (61)	3.1%	1.10 [0.03, 2.17]
Verdijk 2009 (76)	2.4%	0.10 [-1.12, 1.32]
Walker 2010 (64)	1.7%	0.30 [-1.16, 1.76]
Weisgarber 2012 (65)	0.6%	0.20 [-2.29, 2.69]
Subtotal (95% CI)	**20.0%**	**0.70 [0.28, 1.13]**
Heterogeneity: Tau² = 0.00; Chi² = 2.04, df = 5 (P = 0.84); I² = 0%		
Test for overall effect: Z = 3.24 (P = 0.001)		
Not around exercise		
Bell 2017 (66)	6.1%	1.37 [0.60, 2.14]
Chanet 2017 (69)	2.9%	0.50 [-0.62, 1.62]
Daly 2014 (70)	6.0%	0.50 [-0.27, 1.27]
Hoffman 2009 - morning and evening (19)	0.4%	1.70 [-1.44, 4.84]
Leenders 2013 - female (16)	3.0%	0.20 [-0.90, 1.30]
Leenders 2013 - male (16)	2.4%	0.40 [-0.84, 1.64]
Norton 2016 (73)	15.2%	0.61 [0.12, 1.10]
Ottestad 2017 (74)	12.2%	0.00 [-0.54, 0.54]
Snijders 2015 (60)	2.4%	0.20 [-1.01, 1.41]
Tieland 2012 (28)	2.0%	0.10 [-1.23, 1.43]
Tieland 2012a (29)	1.7%	1.60 [0.15, 3.05]
Subtotal (95% CI)	**54.3%**	**0.52 [0.22, 0.82]**
Heterogeneity: Tau² = 0.04; Chi² = 12.02, df = 10 (P = 0.28); I² = 17%		
Test for overall effect: Z = 3.42 (P = 0.0006)		
Total (95% CI)	**100.0%**	**0.55 [0.36, 0.74]**
Heterogeneity: Tau² = 0.00; Chi² = 22.81, df = 25 (P = 0.59); I² = 0%		
Test for overall effect: Z = 5.66 (P < 0.00001)		
Test for subgroup differences: Chi² = 0.54, df = 2 (P = 0.76), I² = 0%		



Wirth et al. 2020 - J Nutr

Efter træning

Før træning og efter træning

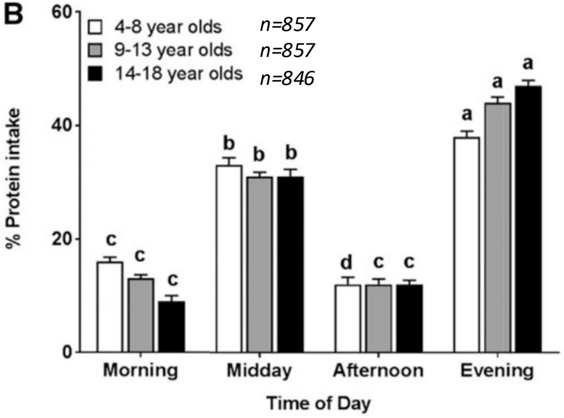
På et andet tidspunkt på dagen

Hvornår skal protein indtages?

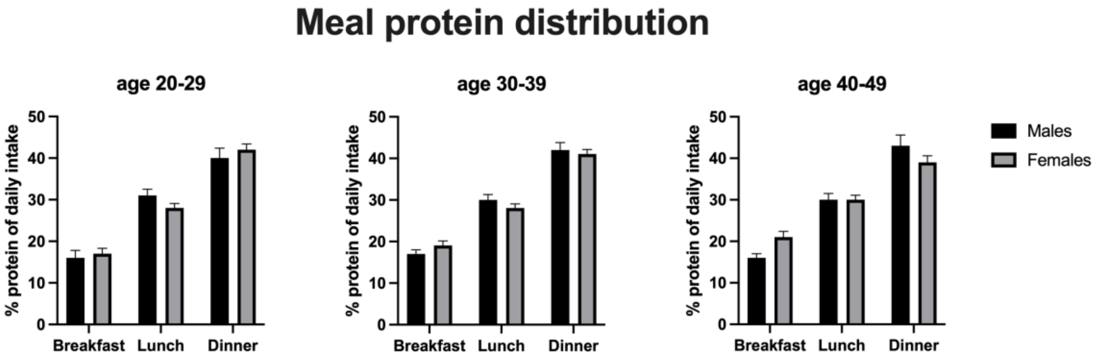
1) ACSM: Atleter: 1.2-2.0 g protein/kg kropsvægt
   - For at understøtte:
     - Metabolisk tilpasninger
     - Vævs reperation og remodelering
     - Protein omsætning

ACSM og ISSN anbefalinger til atleter
0.3 g protein/kg kropsvægt/måltid
- Jævnt fordelt hver 3-4 time

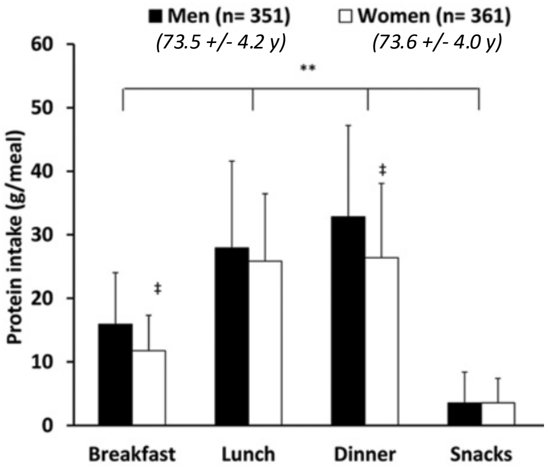
Fordeling af protein indtag



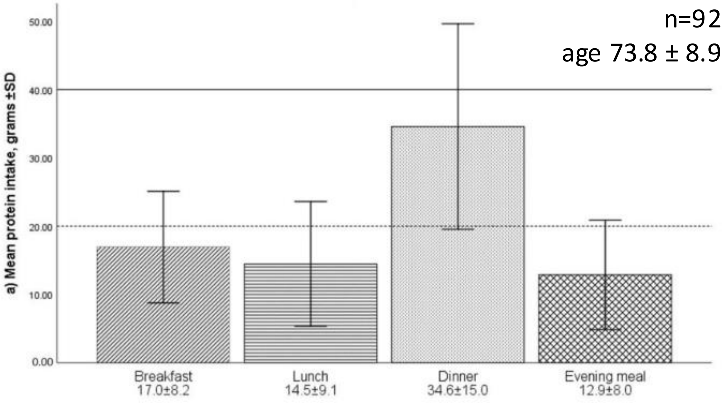
Mathias et al 2017 – J Nutr



U.S. Department of Agriculture ARS 2018

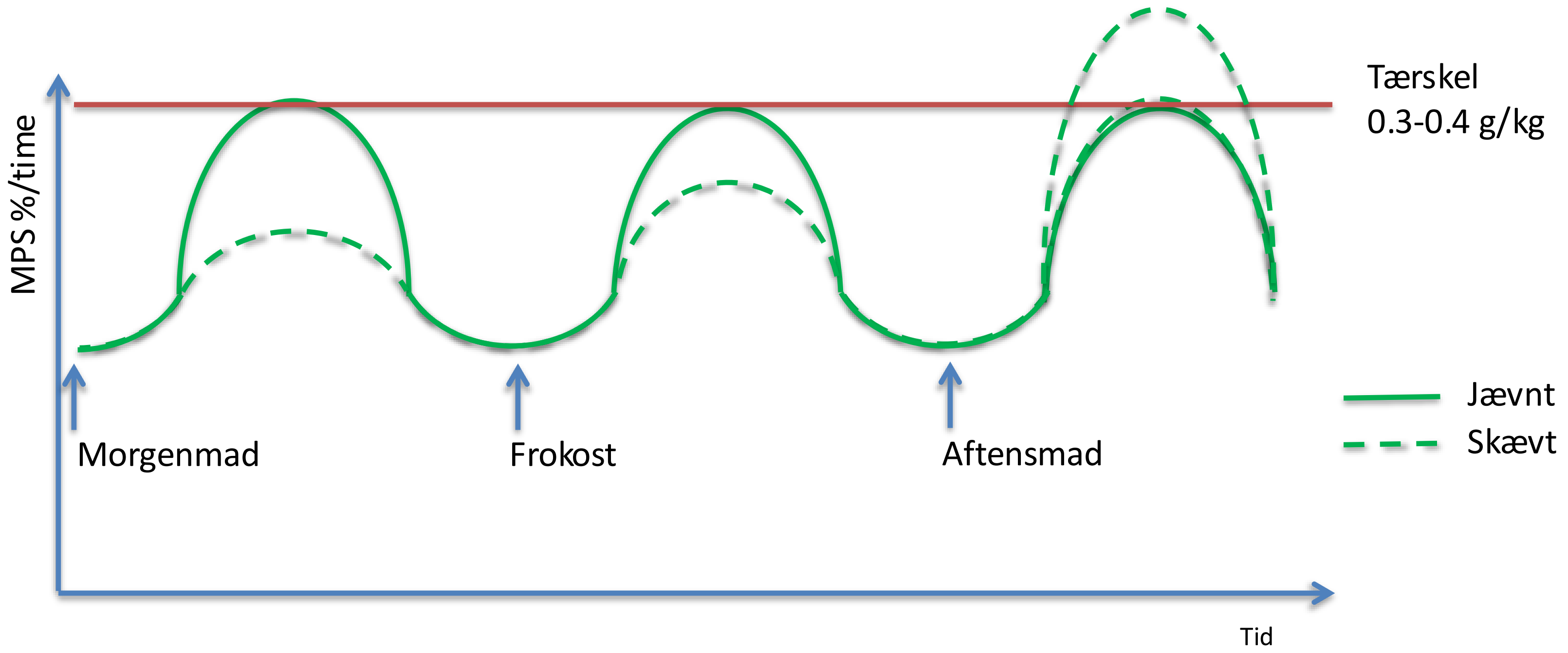


Farsijani et al 2016 – Am J Clin Nutr

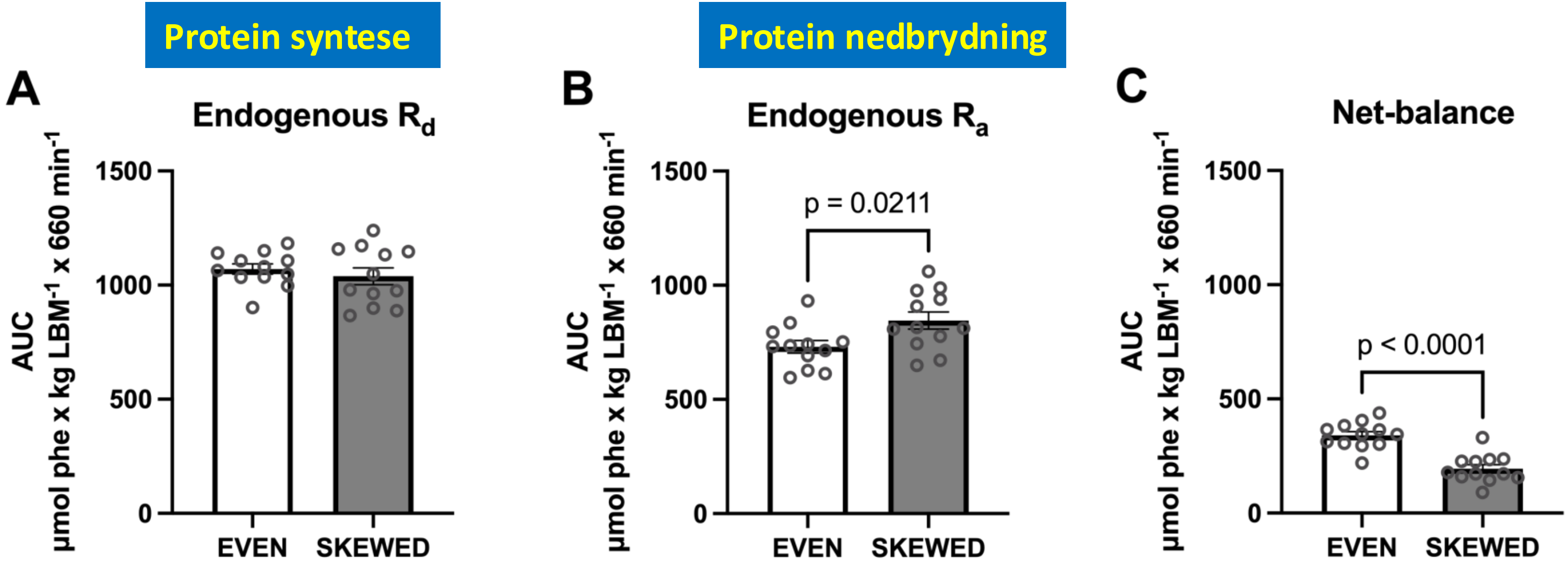


Nygård et al 2020 – Geriatrics

Måtids fordeling



Helkrops protein balance



- Immunfunktion
- Restitution efter sygdom
- Vævsheling
- Bibeholde muskelmasse

Agergaard et al. 2023 Clin Nutr

Myter om proteinindtag

Proteintilskud er nødvendige for at opnå det anbefalede indtag

WHO: RDA = 0.83 g protein/kg kropsvægt

NNR: >65 år: 1.2 g protein/kg kropsvægt

Atleter: 1.6 g protein/kg kropsvægt

Hvor meget protein spiser vi?

I Danmark er det gennemsnitlige proteinindtag 1.0-1.2 g/kg kropsvægt/dag

Pedersen et al 2015, DTU Fødevareinstituttet – Danskernes kostvaner 2011-2013

Protein indhold

100 g ærter = 9 g protein

100 g kogte linser = 9 g protein

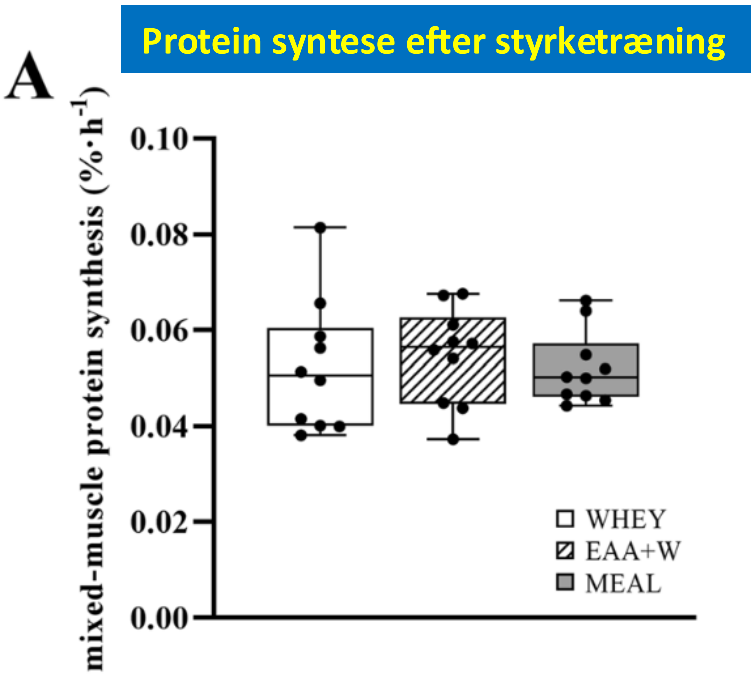
100 g hakkebøf = 18 g protein

1 glas (2 dl) mælk = 7 g protein

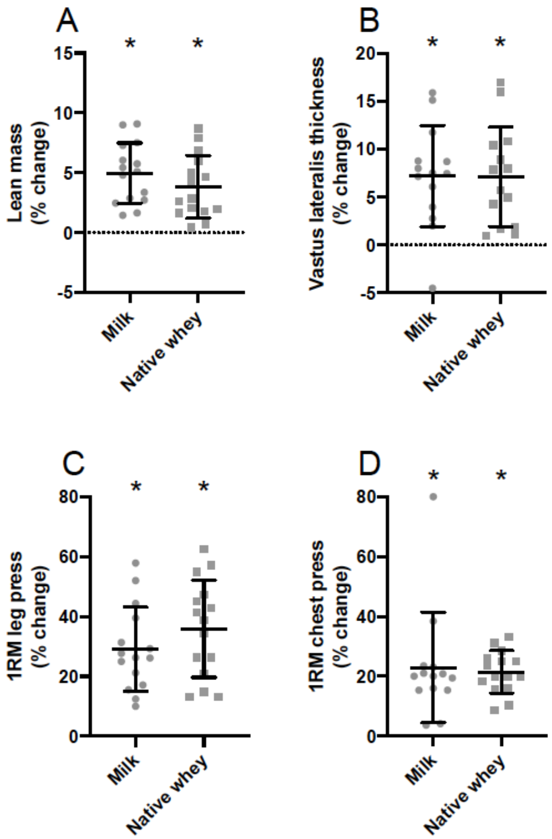
2 dl skyr = 22 g protein

1 æg = 7 g protein

Supplement vs. almindelig kost



Gwin et al 2021 – J Int Soc Sports Nutr



Hamarsland et al. 2019 - Nutrients

Er alt godt så?

Politik

Flere ældre dør af fejl- og underernæring: - De kunne lige så godt have åbnet en dåse hundemad

Aktindsigter viser, at pårørende
"udkogte og vandede" kartofler,
aldrig bliver leveret.

Underernæring - et overset sundhedsproblem

Underernæring er et problem, som desværre bliver overset på hospitalerne og i ældreplejen. Det er et paradoks. For vi ved, hvad der virker effektivt.

Geriatrisk ældre

Indlagte geriatriske patienter
>70 år, n=143

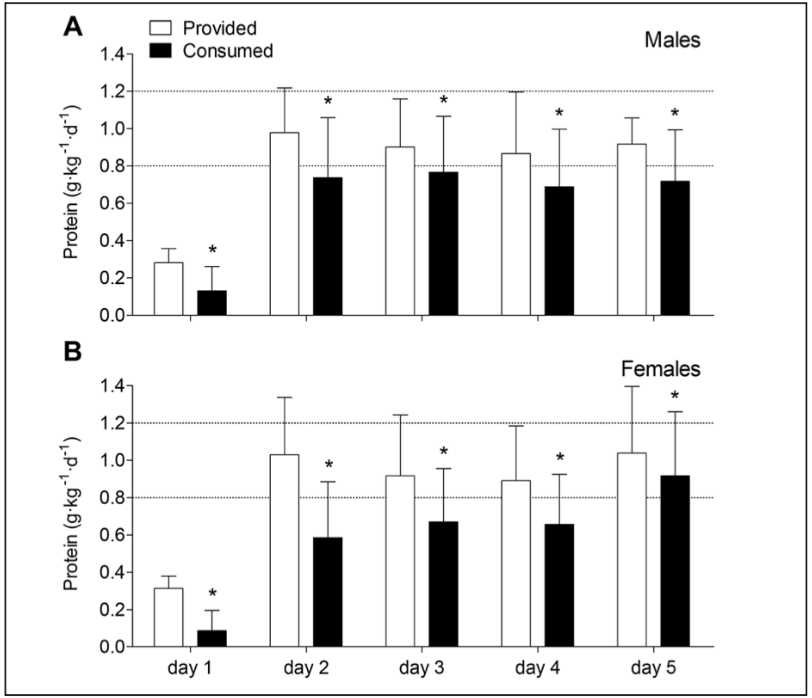
	During the hospital admission†			
	Protein		Placebo	
	Median	Q1, Q3	Median	Q1, Q3
From the diet‡ (*n*)	70		74	
Protein (g/d)	42	36, 52	42	30, 52
Protein (g/kg§ per d)	0·6	0·5, 0·8	0·6	0·5, 0·8

0.6 g protein/kg kropsvægt!

Gade et al 2019 – Br J Nutr

Rehabilitering efter operation

Hofte eller knæalloplastik operation



* Indicates a significant difference when compared with provided food, P<0.001

Weijzen et al 2019 - J Nutr Health Aging

Rehabilitering efter knæalloplastik

EAA (20 g) or placebo twice daily

	Placebo Group* (N = 20)		EAA Group* (N = 19)		
Variable	Baseline	6 Weeks Postop.	Baseline	6 Weeks Postop.	P Value†
Quadriceps					
Involved leg	44.81 ± 3.09	38.31 ± 2.39	48.66 ± 3.45	43.87 ± 2.93	0.03 (0.04)
Contralateral leg	49.98 ± 3.05	46.44 ± 2.94	55.49 ± 3.87	54.41 ± 3.65	0.01 (0.02)
Hamstrings					
Involved leg	63.86 ± 3.33	55.93 ± 2.91	69.32 ± 4.05	63.76 ± 3.41	0.04 (0.04)
Contralateral leg	63.64 ± 3.33	58.75 ± 3.05	69.37 ± 4.19	67.50 ± 3.75	0.01 (0.02)

Atrofi af quadriceps- og hamstringmusklerne var signifikant større i placebogruppen end i EAA-gruppen

Dreyer et al 2018 - JBJS

Take home messages

- For at sikre optimal muskelrehabilitering bør man indtage 1.2-2.0 g protein/kg/dag – dette er opnåeligt gennem en normal kost

- Proteinindtag bør fordeles jævnt gennem dagen via de daglige måltider

- Langt de fleste raske individer får nok protein – men man bør have et større fokus på ældre, især under rehabilitering

Other candidates

Creatine

- aids in the production of ATP (energy source) in the muscles. It can enhance muscle strength, power, and overall muscle mass

Vitamin-D

- deficiency has been linked to reduced muscle strength and function

Omega-3 fatty acid

- anti-inflammatory properties that can help reduce exercise-induced muscle damage and inflammation, enhancing muscle recovery and growth

Leucine, BCAA

- stimulate anabolic signaling and protein synthesis

- …….

Energi tilgængelighed

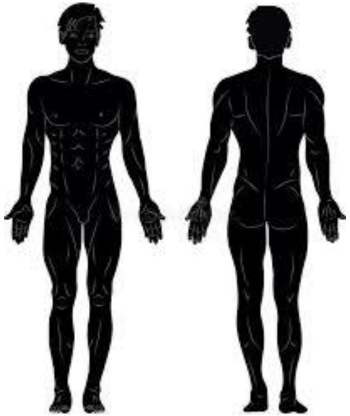
Dagligt kostindtag

−

Dagligt energiforbrug ved træning

=

<u>Energi tilgængeligt</u> til kroppens basale funktioner



Stofskifte, reproduction, knogleomsætning, protein syntese, vækst, immunforsvar, hormoner, ...

<20 kcal/kg FFM/dag

Konsekvens af lav energitilgængelighed under langvarig træning med høj volumen

- Tab af muskelmasse, muskelstyrke og muskelkraft

Tornberg et al. 2017 MSSE; Knechtle and Nikolaidis 2018 Front Physiol; Murphy et al. 2018 Sport Med NZ

- Reduceret niveau af køns- og stofskiftehormoner samt øget niveau af stresshormoner

Tornberg et al. 2017 MSSE; Melin et al. 2023 Scand J Med Sci Sports

- Reduceret eller manglende træningsrespons

Ackerman et al. 2019 Br J Sports Med

- Højere forekomst af skader hos løbere, der oplever vægttab sammenlignet med vægtstabile løbere

Dejong Lempke et al. 2022 Int J Sports Phys Ther

- Hos udholdenhedsatleter er forekomsten af langvarig LEA op til 50%. Specifikt har den i danske elite og sub-eliteatleter vist sig at være 50% for kvinder og 15% hos mænd.

Ackerman et al. 2019 Br J Sports Med, Melin et al. 2023 Scand J Med Sci Sports, Lichtenstein et al. 2024, Clin J Sports Med

Relative Energy Deficiency in Sports - RED-s

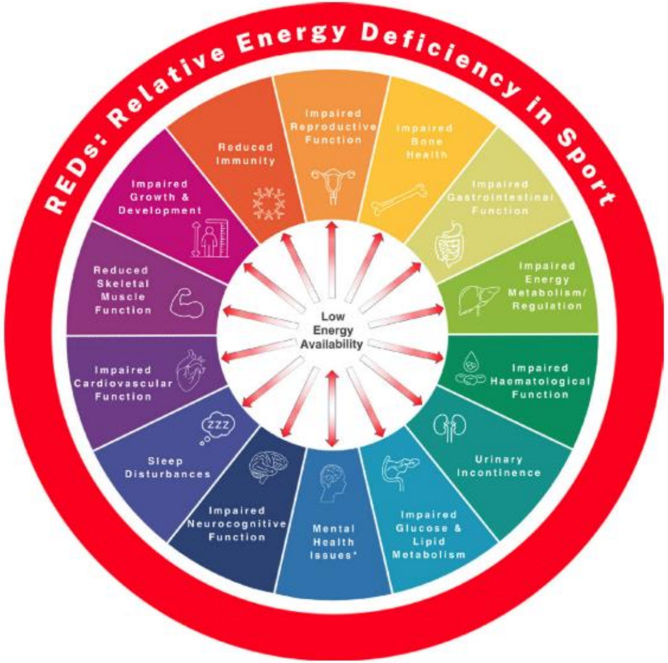


Figure 1 REDs Health Conceptual Model. The effects of LEA exist on a continuum. While some exposure to LEA is mild and transient termed adaptable LEA (arrow depicted in white), problematic LEA is associated with a variety of adverse REDs outcomes (arrow depicted in red). *Mental Health Issues can either precede REDs or be the result of REDs. LEA, low energy availability; REDs, Relative Energy Deficiency in Sport.

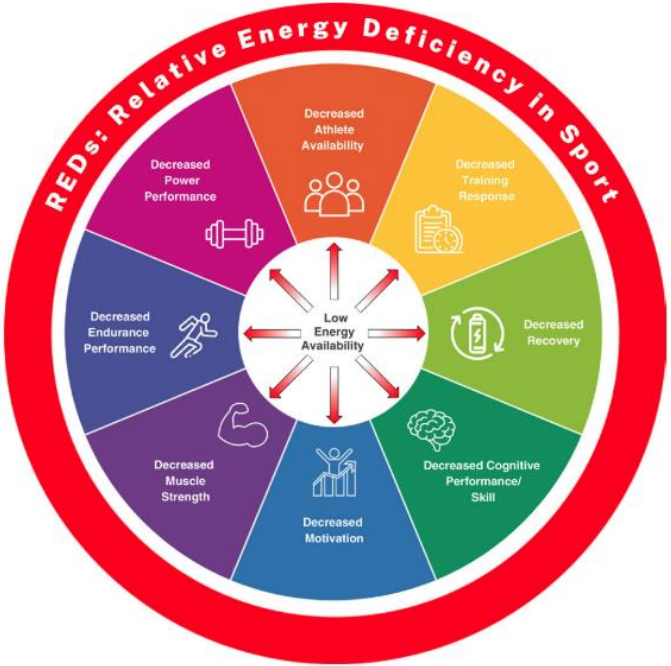


Figure 2 REDs Performance Conceptual Model. The effects of LEA exist on a continuum. While some exposure to LEA is mild and transient, termed adaptable LEA (arrow depicted in white), problematic LEA is associated with a variety of adverse REDs performance outcomes (arrow depicted in red). LEA, low energy availability; REDs, Relative Energy Deficiency in Sport.

Mountjoy et al. 2023 Br J Sports Med

How much protein is needed?

Table 2 Effects of protein supplementation on changes in lean body mass

Groups/subgroups	SMD	95% CI	Number of trials/ intervention groups	*P*-value	I^2 (%)
All RCT	0.22	0.15:0.29	66/93	<0.01	7
RCT without resistance exercise	0.21	-0.15:0.58	6/6	0.38	25
RCT with resistance exercise (RE)	0.22	0.14:0.30	62/87	<0.01	6.2
<65 years old	0.25	0.16:0.35	48/70	<0.01	8.1
≥65 years old	0.13	−0.00:0.28	14/17	0.06	6.2
RCT with RE reporting protein ingestion	0.19	0.11:0.28	51/72	<0.01	6.9
RCT with RE ingesting <1.2 g/kg/day	−0.14	−0.56:0.27	4/4	0.35	0
RCT with RE ingesting 1.2–1.59 g/kg/day	0.17	0.06:0.28	24/34	<0.01	0
<65 years old	0.15	−0.02:0.31	15/23	0.07	2.8
≥65 years old	0.20	0.02:0.37	9/11	0.03	0
RCT with RE ingesting ≥1.6 g/kg/day	0.30	0.17:0.43	23/34	<0.01	0
<65 years old	0.30	0.17:0.43	23/34	<0.01	0
≥65 years old[a]	-	-	-	-	-
Meta regression – protein ingestion as a continuous variable (g/kg BW/day) in all RCT reporting protein ingestion	0.13	−0.00:0.26	55/77	0.06	NA
Meta regression – protein ingestion as a continuous variable (g/kg BW/day) in studies using RE	0.14	0.00:0.27	51/72	0.04	NA

BW, body weight; CI, confidence intervals; NA, not applicable; RCT, randomized clinical trials; RE, resistance exercise; SMD, standardized mean deviation.
[a]No studies in the dataset.

Muscle mass – more than **1.2 g protein**/kg BW/day

Table 4 Effects of protein supplementation on changes in lower-body strength

Groups/subgroups	SMD	95% CI	Number of trials/ intervention groups	*P*-value	I^2 (%)
All RCT reporting lower-body strength	0.20	0.08:0.33	50/70	<0.01	52.8
RCT without resistance exercise	0.14	−0.36:0.64	4/4	0.44	20.4
RCT with resistance exercise (RE)	0.21	0.08:0.34	47/66	<0.01	54.5
<65 years old	0.19	0.03:0.36	35/52	0.02	52.8
≥65 years old	0.25	0.01:0.48	12/14	0.04	60.6
RCT with RE reporting protein ingestion	0.21	0.08:0.34	41/56	<0.01	49.5
Ingesting <1.2 g/kg/day	−0.01	−1.85:1.83	2/2	0.95	0
Ingesting 1.2–1.59 g/kg/day	0.08	−0.10:0.27	20/28	0.37	51.6
Ingesting ≥1.6 g/kg/day	0.40	0.23:0.57	19/26	<0.01	26.1
<65 years old	0.38	0.19:0.56	17/24	<0.01	62
≥65 years old	0.55	0.04:1.06	2/2	0.03	0
Meta regression – protein ingestion as a continuous variable (g/kg BW/day) in all RCT reporting protein ingestion	0.25	0.05:0.45	44/60	0.016	NA
Meta regression – protein ingestion as a continuous variable (g/kg BW/day) in studies using RE	0.26	0.05:0.47	41/56	0.014	NA

BW, body weight; CI, confidence intervals; NA, not applicable; RCT, randomized clinical trials; RE, resistance exercise; SMD, standardized mean deviation.

Muscle strength – more than **1.6 g protein**/kg BW/day

Nunes et al. 2022 J Cachexia Sarcopenia Muscle