NUTRITIONAL INTERVENTIONS TO IMPROVE MUSCLE STRENGTH AND FUNCTION IN THE ELDERLY

Prof Lisa Wood
School of Biomedical Science and Pharmacy
University of Newcastle
and
Hunter Medical Research Institute, NSW, Australia
Email: lisa.wood@newcastle.edu.au

DECLARATIONS

Speaker Honoraria/ Travel Grants:

Australian Nutrition Trust
National Asthma Council
Thoracic Society of Australia & New Zealand
NSA LLC
DSM Nutritional Products
CGi LLC
Boehringer-Ingelheim

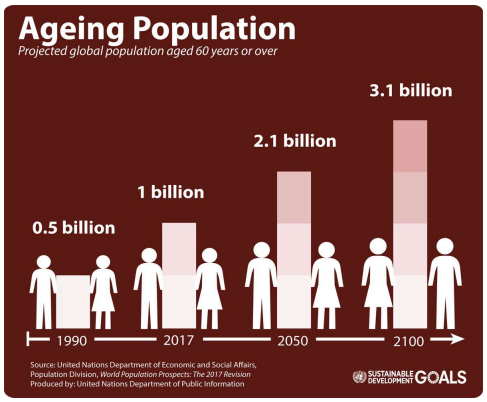
Research grants:

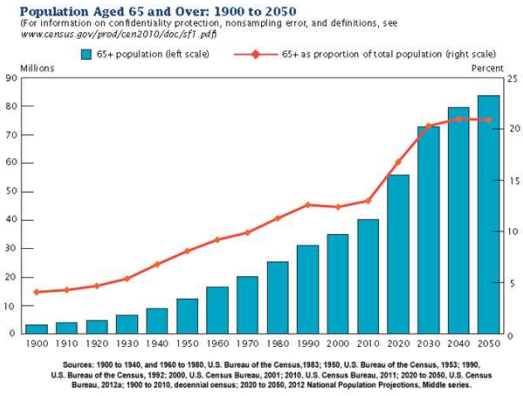
National Health and Medical Research Council
Asthma Australia
NSA LLC
Australian Health & Nutrition Association Ltd
DSM Nutritional Products
Healthworld
Novartis

OUTLINE

- Aging and body composition
- Sarcopenia: definition, diagnosis, prevalence, consequences, mechanisms
- Nutritional approaches to improving muscle mass, strength and function
  - Protein
  - Protein combined with exercise
  - Other nutritional strategies (vitamin D, antioxidants, omega-3 fatty acids)
- Recommendations for clinicians

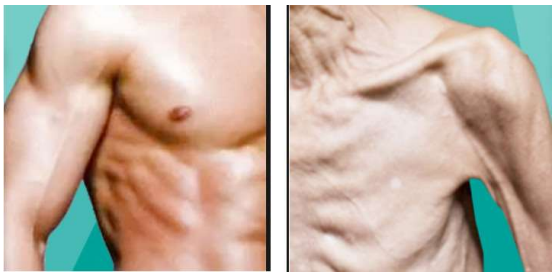
THE AGING POPULATION

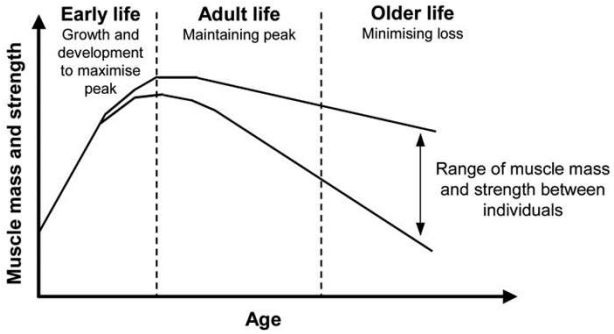




HEALTH EFFECTS

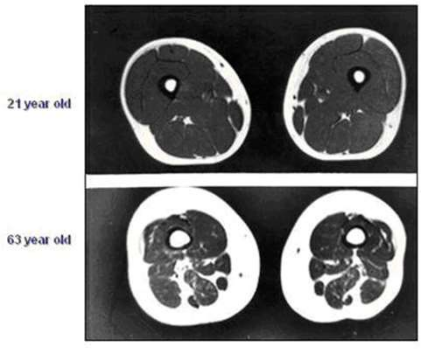
AGING AND BODY COMPOSITION



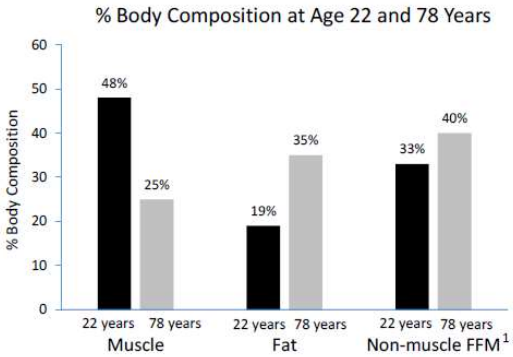


(Sayer, J Nutr Health Aging, 2008)

AGING AND BODY COMPOSITION



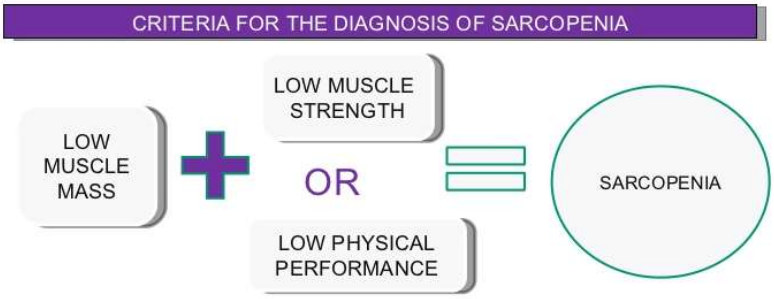
Age-related changes in muscle mass in thigh cross-sectional area of two people with similar BMI



(Roubenoff R, et al. J Gerontol A Biol Sci Med Sci 55: M716-24, 2000; Nowson et al, Nutrients, 2015)

SARCOPENIA: DEFINITION & DIAGNOSIS

Sarcopenia is a syndrome characterised by progressive and generalised loss of skeletal muscle mass and strength/performance with a risk of adverse outcomes such as physical disability, poor quality of life and death.



(Cruz-Jentoft, et al. Report of the EWGSOP: European Working Group on Sarcopenia in Older People, Age & Aging, 2010)

SARCOPENIA: DIAGNOSIS

Sarcopenia staging, which reflects the severity of the condition, is a concept that can help guide clinical management of the condition.

Stage	Muscle mass	Muscle strength	Performance
Presarcopenia	↓		
Sarcopenia	↓	↓	Or ↓
Severe sarcopenia	↓	↓	↓

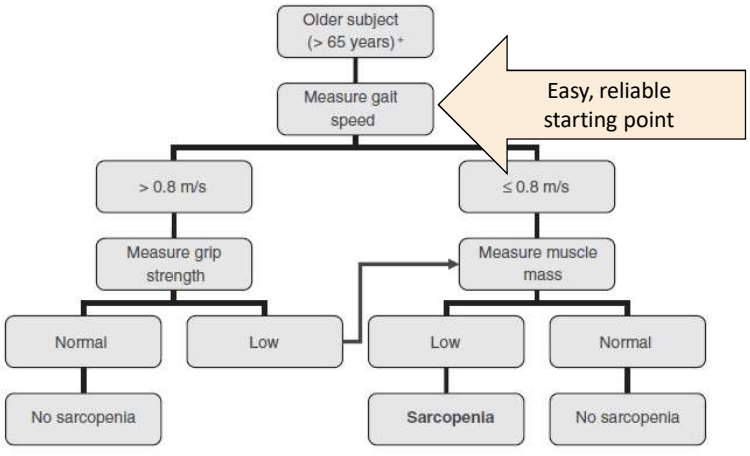
(Cruz-Jentoft et al, Age & Aging, 2010)

SARCOPENIA: DIAGNOSIS

MUSCLE MASS	MUSCLE STRENGTH	PHYSICAL PERFORMANCE
• BIA • DEXA • CT • MRI	• Handgrip strength • Knee flexion-extension • PEF	• SPPB • Gait speed • Get up&Go • Stair climbing

(Cruz-Jentoft, et al. Age & Aging, 2010)

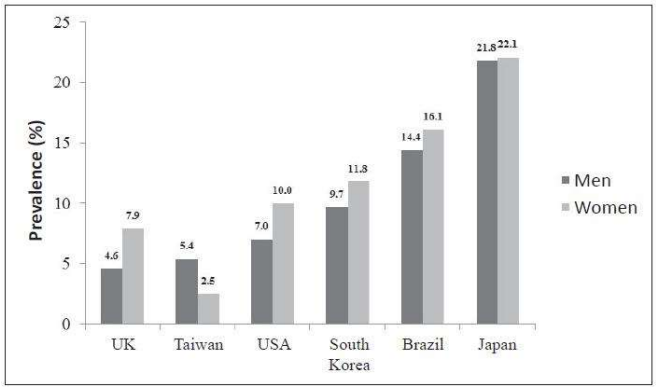
SARCOPENIA: DIAGNOSIS



(Cruz-Jentoft, et al. Age & Aging, 2010)

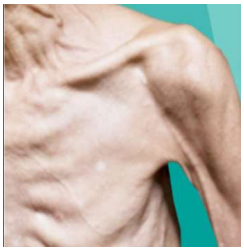
SARCOPENIA: PREVALENCE

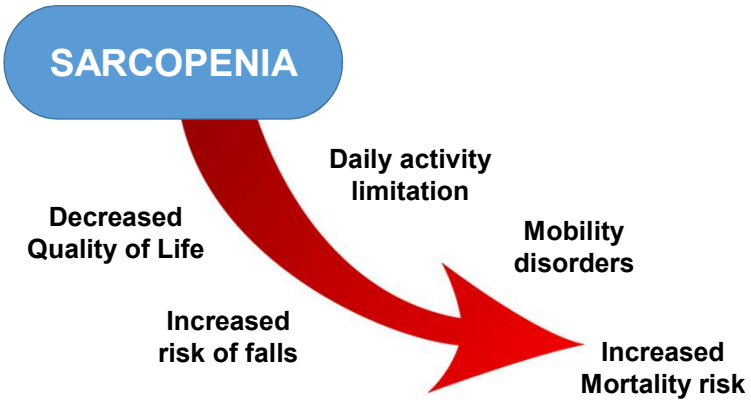
(individuals >60 years)



(Diz, Rev Bras Geriatr Gerontol, 2015)

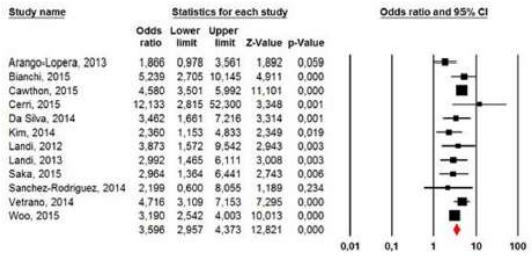
SARCOPENIA: HEALTH CONSEQUENCES





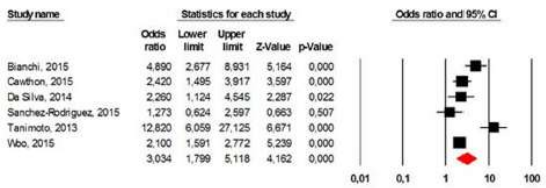
SARCOPENIA: HEALTH CONSEQUENCES

- **Higher Mortality: OR 3.6 (95% CI 2.9-4.4)**



Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Arango-Lopera, 2013	1,866	0,978	3,561	1,892	0,059
Bianchi, 2015	5,239	2,705	10,145	4,911	0,000
Cawthon, 2015	4,580	3,501	5,992	11,101	0,000
Cerri, 2015	12,133	2,815	52,300	3,348	0,001
Da Silva, 2014	3,462	1,661	7,216	3,314	0,001
Kim, 2014	2,360	1,153	4,833	2,349	0,019
Landi, 2012	3,873	1,572	9,542	2,943	0,003
Landi, 2013	2,992	1,465	6,111	3,008	0,003
Saka, 2015	2,964	1,364	6,441	2,743	0,006
Sanchez-Rodriguez, 2014	2,199	0,600	8,055	1,189	0,234
Vetrano, 2014	4,716	3,109	7,153	7,295	0,000
Woo, 2015	3,190	2,542	4,003	10,013	0,000
	3,596	2,957	4,373	12,821	0,000

- **Functional decline: OR 3.0 (1.8-5.1)**

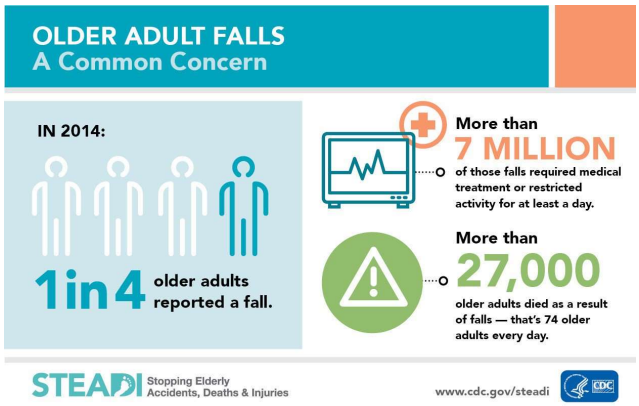


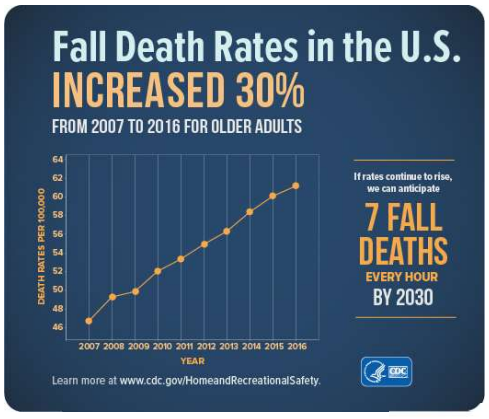
Study name	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Bianchi, 2015	4,890	2,677	8,931	5,164	0,000
Cawthon, 2015	2,420	1,495	3,917	3,597	0,000
Da Silva, 2014	2,260	1,124	4,545	2,287	0,022
Sanchez-Rodriguez, 2015	1,273	0,624	2,597	0,663	0,507
Tanimoto, 2013	12,820	6,059	27,125	6,671	0,000
Woo, 2015	2,100	1,591	2,772	5,239	0,000
	3,034	1,799	5,118	4,162	0,000

- **Increased Hospitalisations**
- **Increased Falls**

(Beaudart C et al, PLoS ONE, 2017)

SARCOPENIA: HEALTH CONSEQUENCES





SARCOPENIA: MECHANISMS

Primary
Age-related

- Sex hormones
- Apoptosis
- Mitochondrial dysfunction

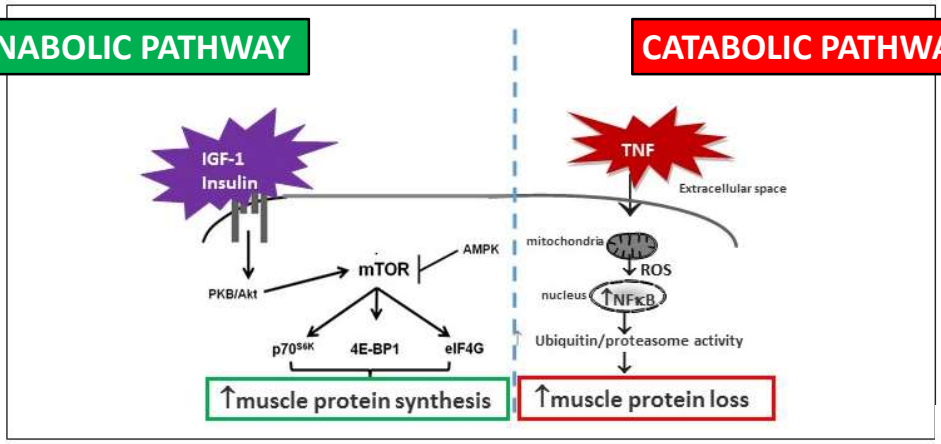
Secondary

Activity related	• Bed rest • Sedentary lifestyle • Deconditioning
Disease related	• Advanced organ failure • Inflamatory diseases • Malignancy • Endocrine diseases
Nutrition related	• Inadequate diet • Malabsortion • Gastrointestinal disorders • Drug induced anorexia

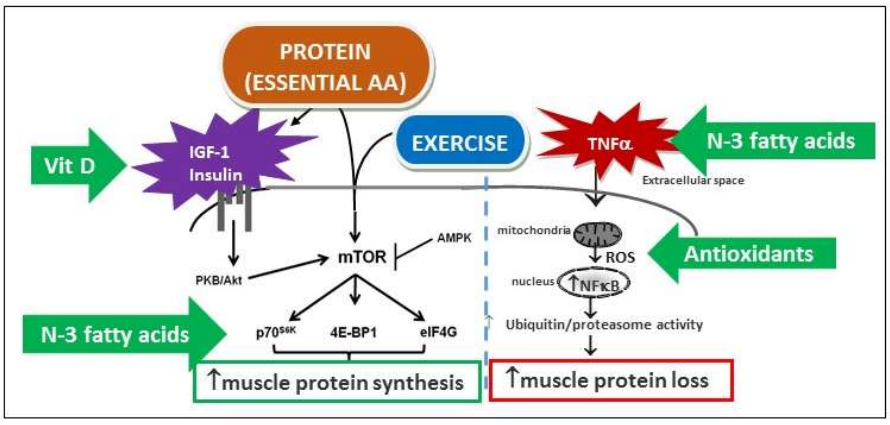
(Cruz-Jentoft, et al. Age & Aging, 2010)

SARCOPENIA: MECHANISMS

SARCOPENIA: MOLECULAR MECHANISMS



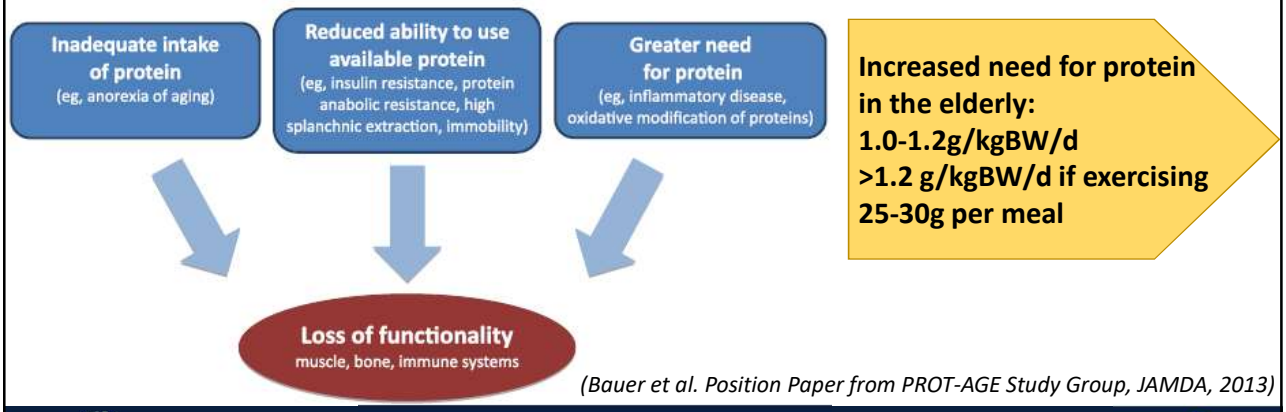
SARCOPENIA: MOLECULAR MECHANISMS



NUTRITIONAL APPROACHES

NUTRITIONAL INTERVENTIONS: PROTEIN

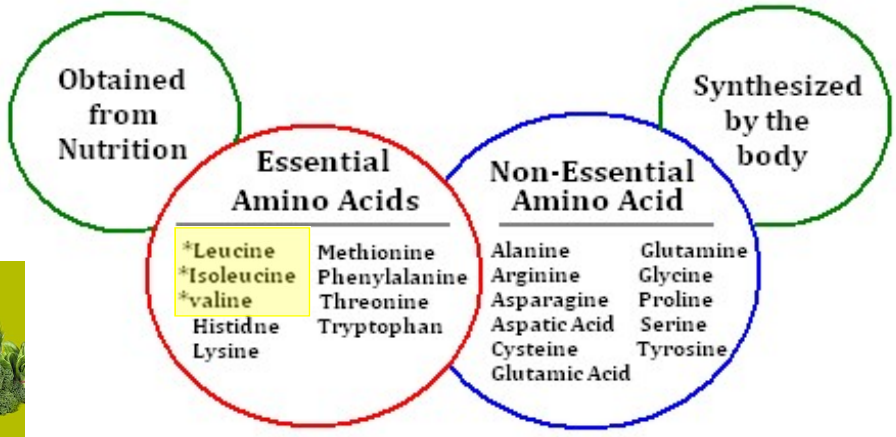
Aging-related causes of protein shortfall:



(Bauer et al. Position Paper from PROT-AGE Study Group, JAMDA, 2013)

NUTRITIONAL INTERVENTIONS: PROTEIN

PROTEIN QUALITY:
is the digestibility and quantity of essential amino acids (needed for muscle synthesis)



*branched chain amino acids

NUTRITIONAL INTERVENTIONS: PROTEIN

PROTEIN QUALITY:

Protein quality scores highest for animal-based proteins and soy.

Most studies to date, animal-based proteins

DIAAS, digestible indispensable amino acid score
PDCAAS, protein digestibility–corrected amino acid score

	DIAAS	PDCAAS
Milk Protein Concentrate	1.18	1.00
Whey Protein Isolate	1.09	1.00
Whey Protein Concentrate	0.973	1.00
Soy Protein Isolate	0.898-0.906	0.979-1.00
Cooked peas	0.579	0.597
Cooked beans	0.588	0.648
Cooked rice	0.595	0.616
Cooked rolled oats	0.542	0.670
Wheat bran	0.411	0.525

(Rutherford et al. J Nutr, 2015)

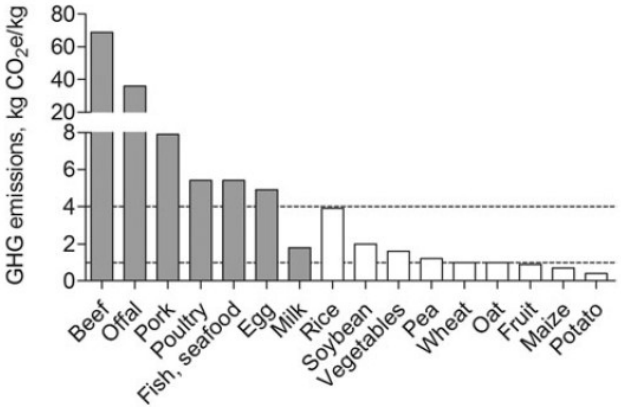
NUTRITIONAL INTERVENTIONS: PROTEIN

PROTEIN QUALITY:
Estimated greenhouse gas (GHG) emissions for common animal (grey) and plant-based (white) proteins;

Environmental impact greater for animal proteins;

- Health effects of plant proteins need exploration.

(Gorissen et al. Proc Nutr Soc, 2017)



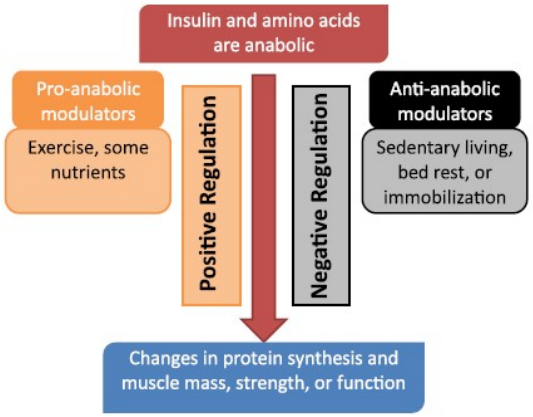
NUTRITIONAL INTERVENTIONS: PROTEIN

TIMING WRT MEALS:

- Both 'between meal' and 'with meal' supplements improve lean mass;
- 'Between meal' supplements also increase fat mass

(Hudson et al, Nutr Rev, 2018)

NUTRITIONAL INTERVENTIONS: PROTEIN & RESISTANCE EXERCISE



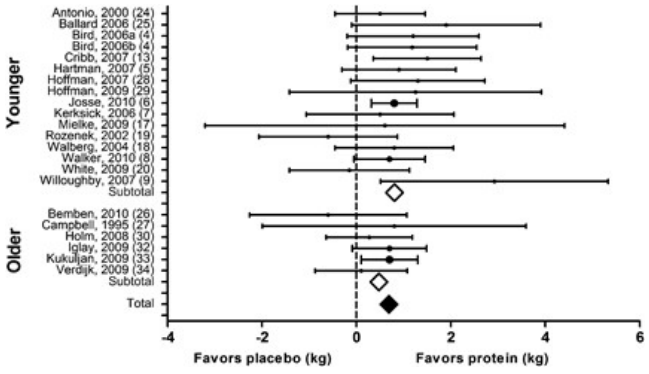
(Bauer et al, JAMDA, 2013)

NUTRITIONAL INTERVENTIONS: PROTEIN & RESISTANCE EXERCISE

- N=680
- 22 RCTs
- Protein dose:
  - mean: 42 g/day
  - range: 6-106 g/day
- Resistance exercise frequency:
  - 3 days/week
- Duration of intervention:
  - mean: 12 weeks
  - range: 6-24 weeks

(Cermak et al, Am J Clin Nutr 2012

Fat Free Mass

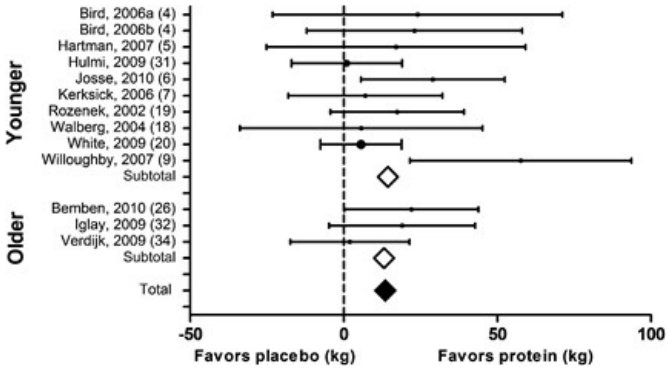


NUTRITIONAL INTERVENTIONS: PROTEIN & RESISTANCE EXERCISE

- N=680
- 22 RCTs
- Protein dose:
  - mean: 42 g/day
  - range: 6-106 g/day
- Resistance exercise frequency:
  - 3 days/week
- Duration of intervention:
  - mean: 12 weeks
  - range: 6-24 weeks

(Cermak et al, Am J Clin Nutr 2012)

Leg Press Strength (1-RM)

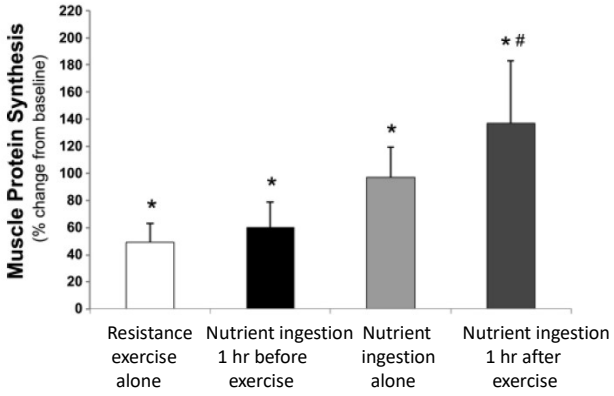


NUTRITIONAL INTERVENTIONS: PROTEIN & RESISTANCE EXERCISE

TIMING WRT EXERCISE:

- Muscle protein synthesis during 2 hr post recovery period.
- Nutrient ingestion post exercise maximises protein synthesis

(Drummond et al, J Appl Phys 2009)

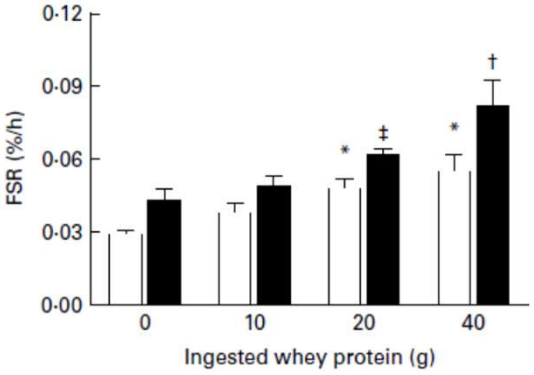


NUTRITIONAL INTERVENTIONS: PROTEIN & RESISTANCE EXERCISE

DOSE WRT EXERCISE:

- Muscle synthesis increased above fasting rates at 20g/d
- Even greater benefits may be gained using higher doses in the elderly

(Yang et al, Br J Nutr 2012)



White bars= no exercise; black bars = exercise; *†‡ p<0.05 vs 0g

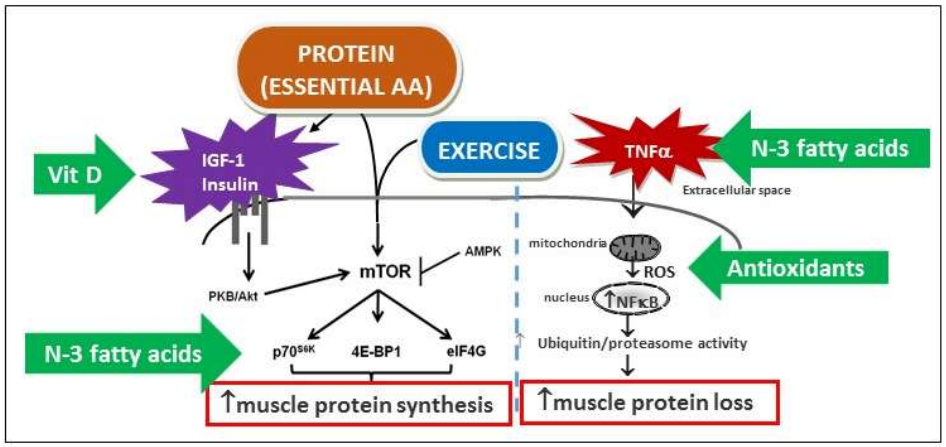
NUTRITIONAL INTERVENTIONS: PROTEIN & RESISTANCE EXERCISE

RECOMMENDATIONS:

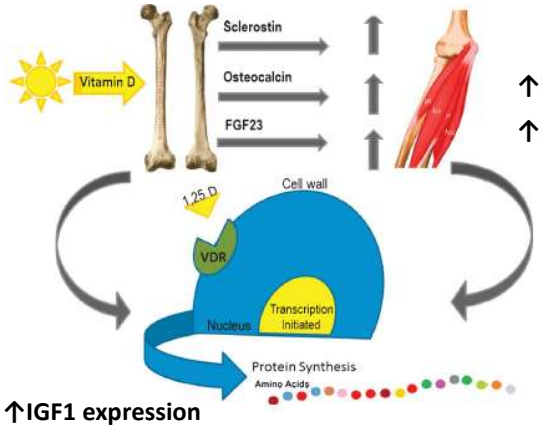
- Older people need more dietary protein; 1.0-1.2 g/kg BW/d^ When exercising, achieve intake of at least 1.2g protein/kg BW/d.*
- Per-meal anabolic threshold of amino acid intake is higher in older individuals (25-30g protein per meal). Enrichment with leucine or branched chain amino acids may help; further studies needed.
- Endurance exercise recommended for 30 minutes per day where safe and tolerated. Include progressive resistance training; consider 2-3 times per week for 10-15 minutes.*
- Timing of protein supplementation; some evidence supports protein consumption after exercise* (consider 20g protein supplement after exercise)*; some evidence supports consumption with meals
- More research studies with better methodologies needed on protein needs in older adults.*

*(^1.2-1.5 g in acute/chronic disease, excludes severe kidney disease (eGFR<30mm/min/1.73m^2); *Bauer, PROT-AGE, JAMDA, 2013)*

NUTRITIONAL INTERVENTIONS: WHAT ELSE??



NUTRITIONAL INTERVENTIONS: VITAMIN D



↑insulin sensitivity

↑mitochondrial function

↑IGF1 expression

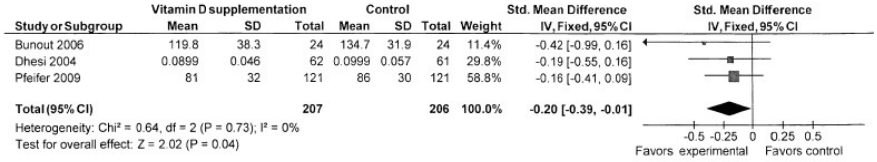
NUTRITIONAL INTERVENTIONS: VITAMIN D

- 13 RCTs
- Age: mean: 78 yr
  range: (63-99 yr)
- Dose: 800-1000 IU/day*
- Duration: 2-36 months

**All studies using >800 IU/day showed benefit.*

Also the dose recommended by the International Osteoporosis Foundation for older people.

Balance Sway

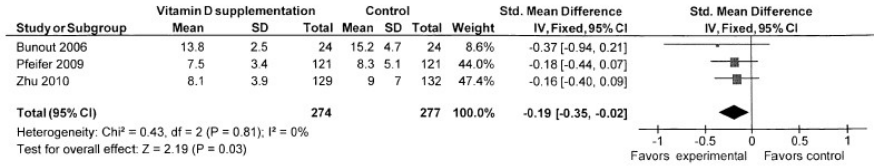


Study or Subgroup	Vitamin D supplementation Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Bunout 2006	119.8	38.3	24	134.7	31.9	24	11.4%	-0.42 [-0.99, 0.16]
Dhesi 2004	0.0899	0.046	62	0.0999	0.057	61	29.8%	-0.19 [-0.55, 0.16]
Pfeifer 2009	81	32	121	86	30	121	58.8%	-0.16 [-0.41, 0.09]
Total (95% CI)			**207**			**206**	**100.0%**	**-0.20 [-0.39, -0.01]**

Heterogeneity: Chi² = 0.64, df = 2 (P = 0.73); I² = 0%
Test for overall effect: Z = 2.02 (P = 0.04)

Std. Mean Difference IV, Fixed, 95% CI
-0.5 -0.25 0 0.25 0.5
Favors experimental Favors control

Timed Up and Go



Study or Subgroup	Vitamin D supplementation Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Bunout 2006	13.8	2.5	24	15.2	4.7	24	8.6%	-0.37 [-0.94, 0.21]
Pfeifer 2009	7.5	3.4	121	8.3	5.1	121	44.0%	-0.18 [-0.44, 0.07]
Zhu 2010	8.1	3.9	129	9	7	132	47.4%	-0.16 [-0.40, 0.09]
Total (95% CI)			**274**			**277**	**100.0%**	**-0.19 [-0.35, -0.02]**

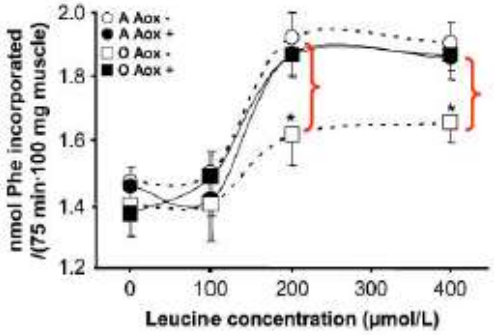
Heterogeneity: Chi² = 0.43, df = 2 (P = 0.81); I² = 0%
Test for overall effect: Z = 2.19 (P = 0.03)

Std. Mean Difference IV, Fixed, 95% CI
-1 -0.5 0 0.5 1
Favors experimental Favors control

NUTRITIONAL INTERVENTIONS: ANTIOXIDANTS

- Human RCTs needed

Mouse model (7 wk): Vit E, Vit C, rutin, Zn, Se



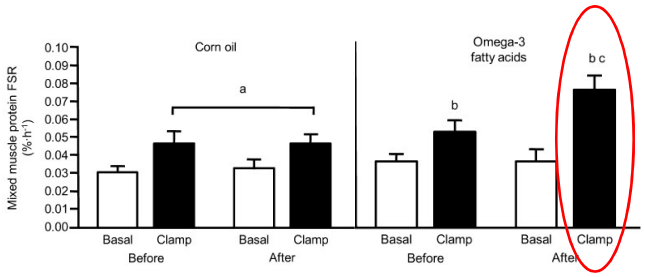
(Marzani, J Nutr, 2008)

Protein synthesis reduced in older rats *without* antioxidant supplementation

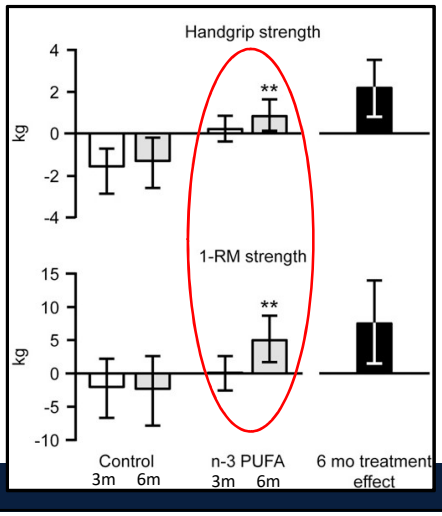
NUTRITIONAL INTERVENTIONS: OMEGA-3 FATTY ACIDS

RCT, n=16 older adults (65+ yr)
Omega-3 fatty acids (3.3g/d) doubled anabolic response to amino acids and insulin. *(Smith, AJCN, 2011)*

Muscle protein synthesis rate



RCT, n=60 adults (60-85 yr)
6m omega-3 fatty acids(3.3g/d) increased thigh muscle volume, handgrip, muscle strength *(Smith, AJCN, 2015)*



RECOMMENDATIONS FOR CLINICIANS

Avoid sarcopenia and its many negative health outcomes:

Dietary Protein
- Protein intake: 1.0-1.2g/kg BW/day, increase to >1.2g if exercising
- Per meal: 25-30g protein
- Consume protein supplements *with* meals

Exercise Training
- Endurance exercise for 30 min per day
- Include resistance exercise 2-3 times per week, for 10-15min
- Supplement with 20g protein *after* exercise

Other Nutrients
- Supplement with 800-1000 IU/day Vitamin D
- Antioxidants and omega-3 fatty acids beneficial, supplemental doses undefined; consume diet high in fruit and vegetables and oily fish

HMRI Hunter Medical Research Institute | The University of Newcastle Australia | NSW Government Health Hunter New England Local Health District

THANKYOU!