The Nutrition Society

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KING'S College LONDON

Beyond protein content to optimise musculoskeletal health: Interactions in the dairy matrix

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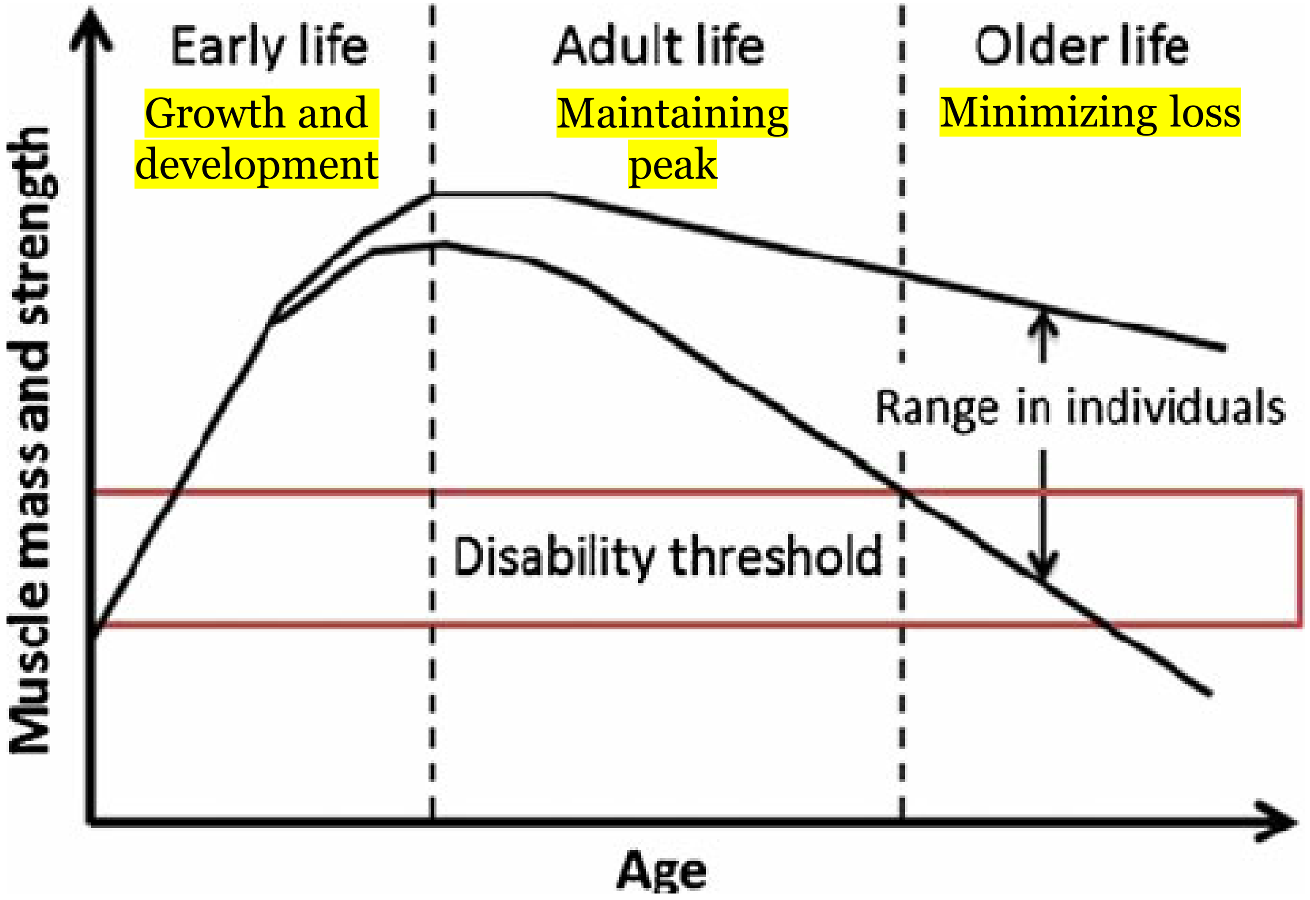
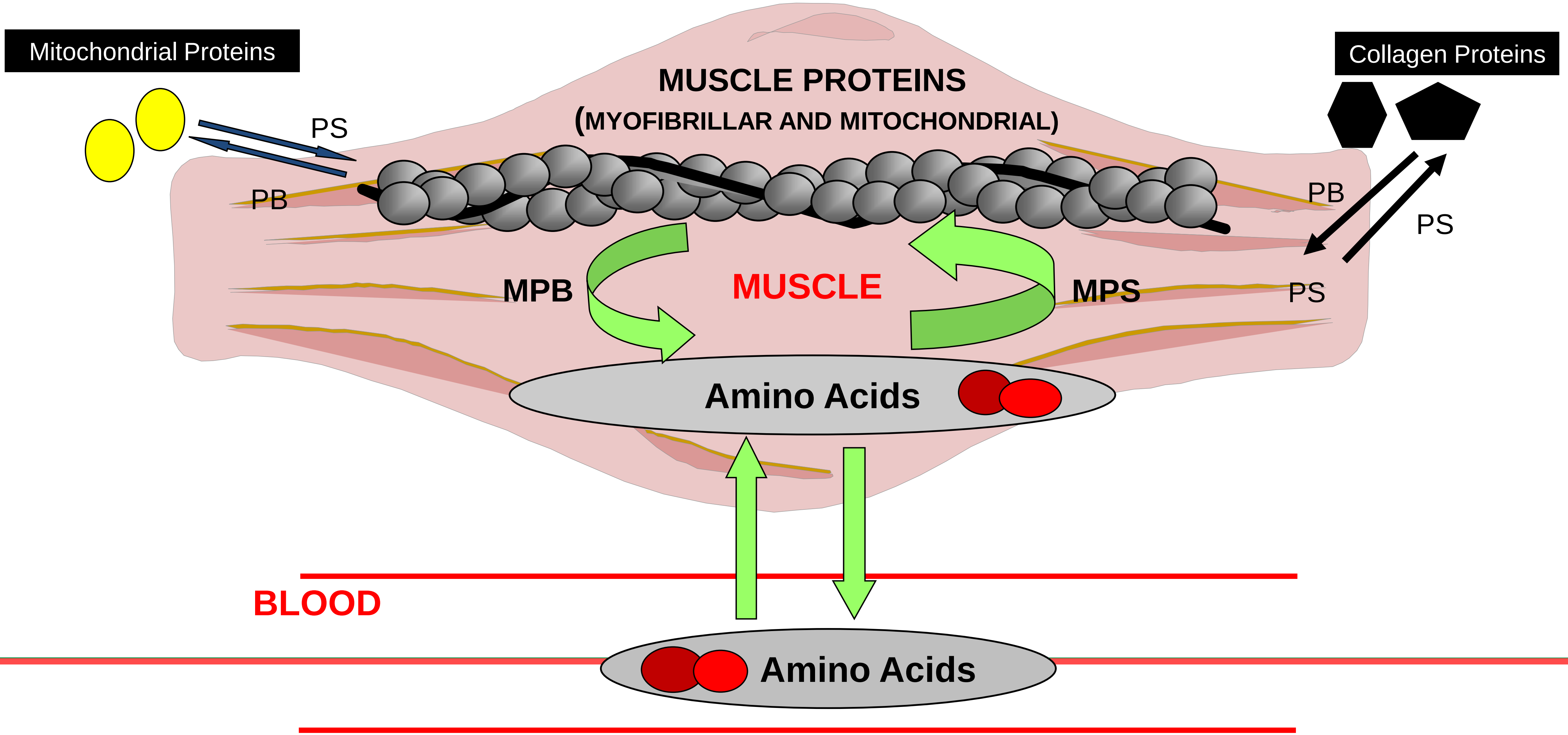
Changes in skeletal muscle mass and strength across the life-span

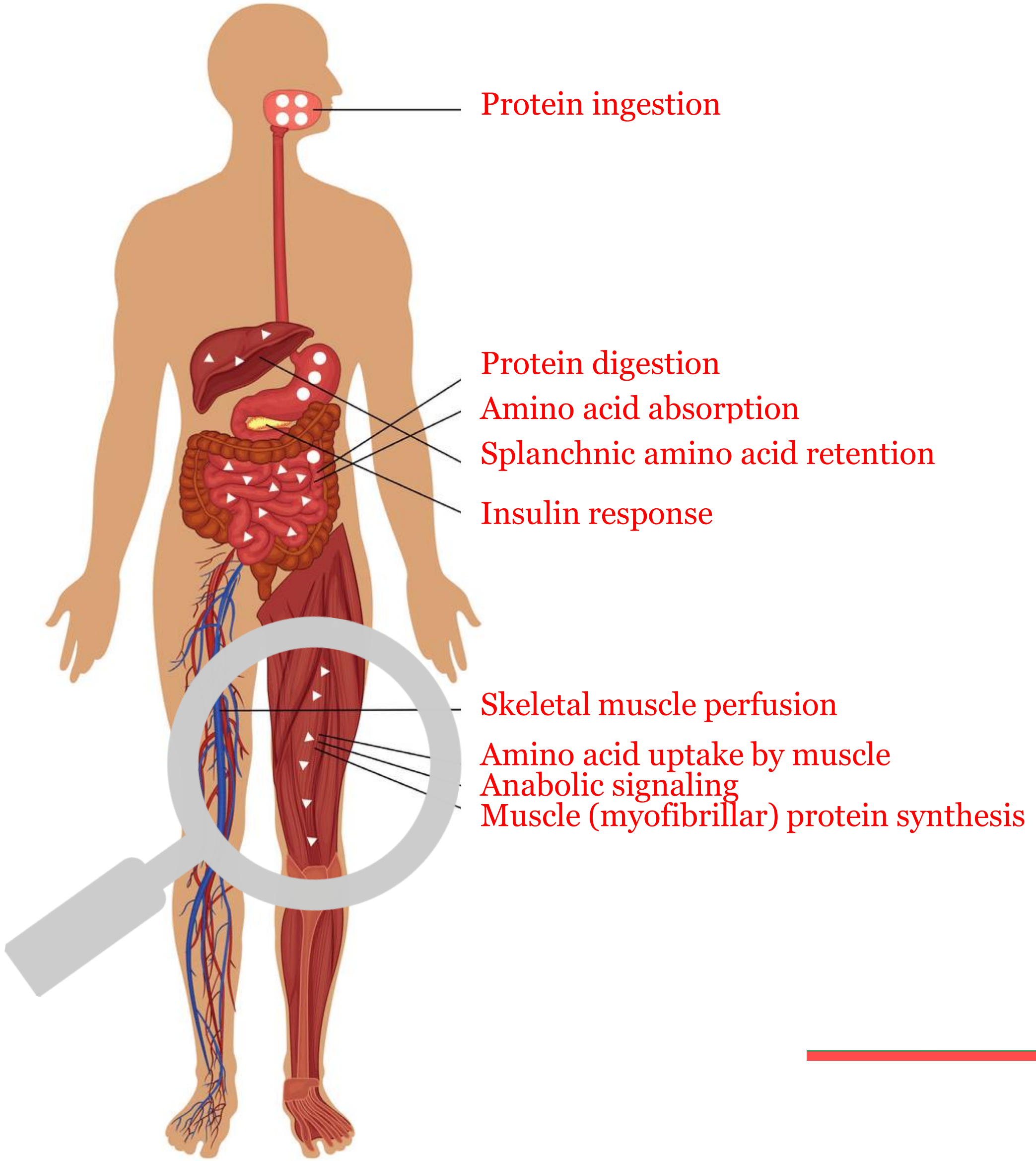


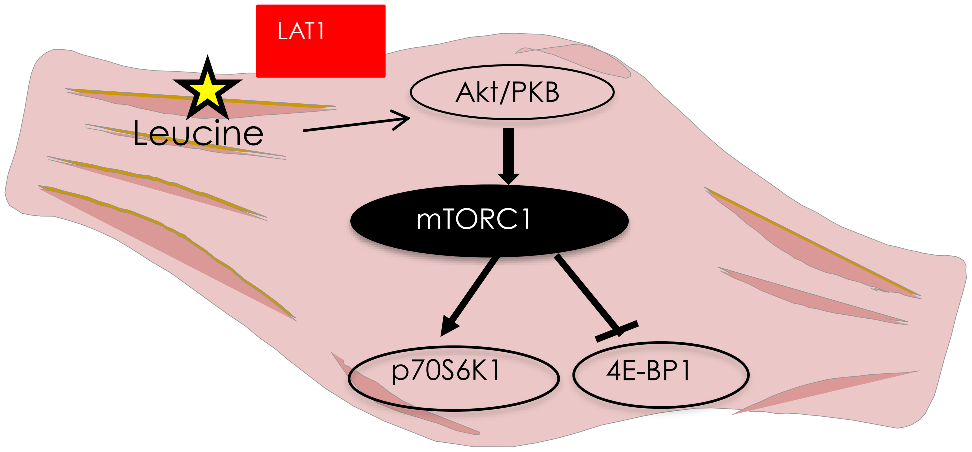
Sayer et al. 2013, Age and Ageing 42: 145-150

The key metabolic process that underpins changes in muscle mass *and strength* in otherwise healthy individuals is muscle protein synthesis

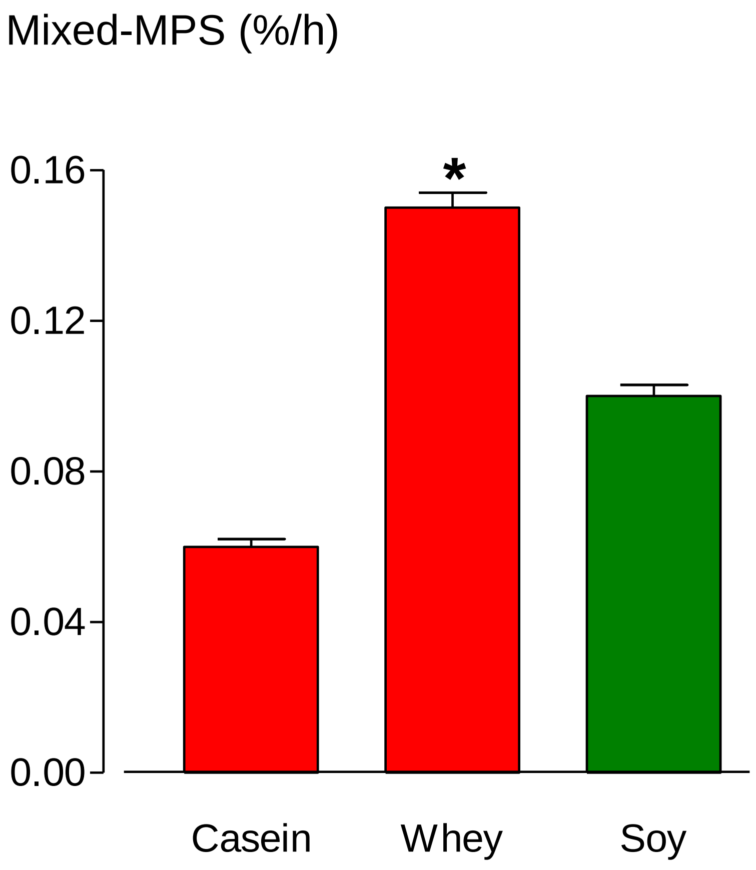


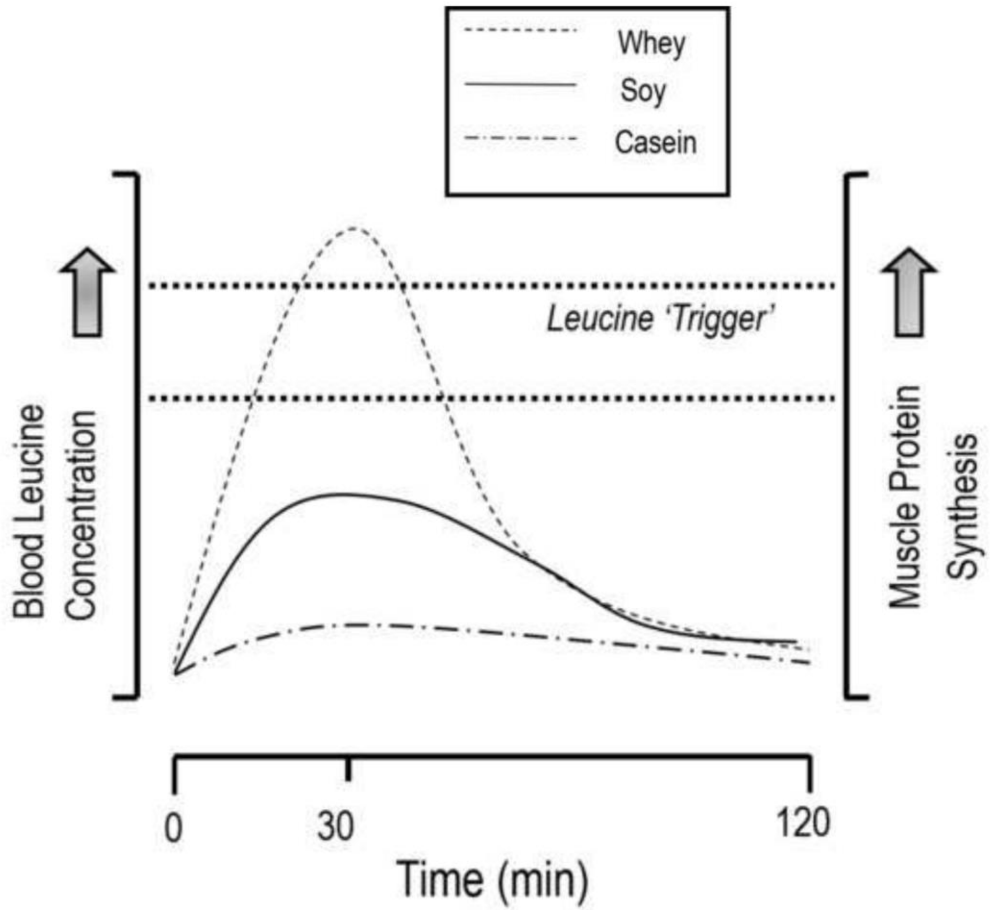
The magnitude of the muscle protein synthetic response to protein ingestion is regulated on several levels of physiology





Isolated dairy proteins have been central to understanding the postprandial regulation of MPS

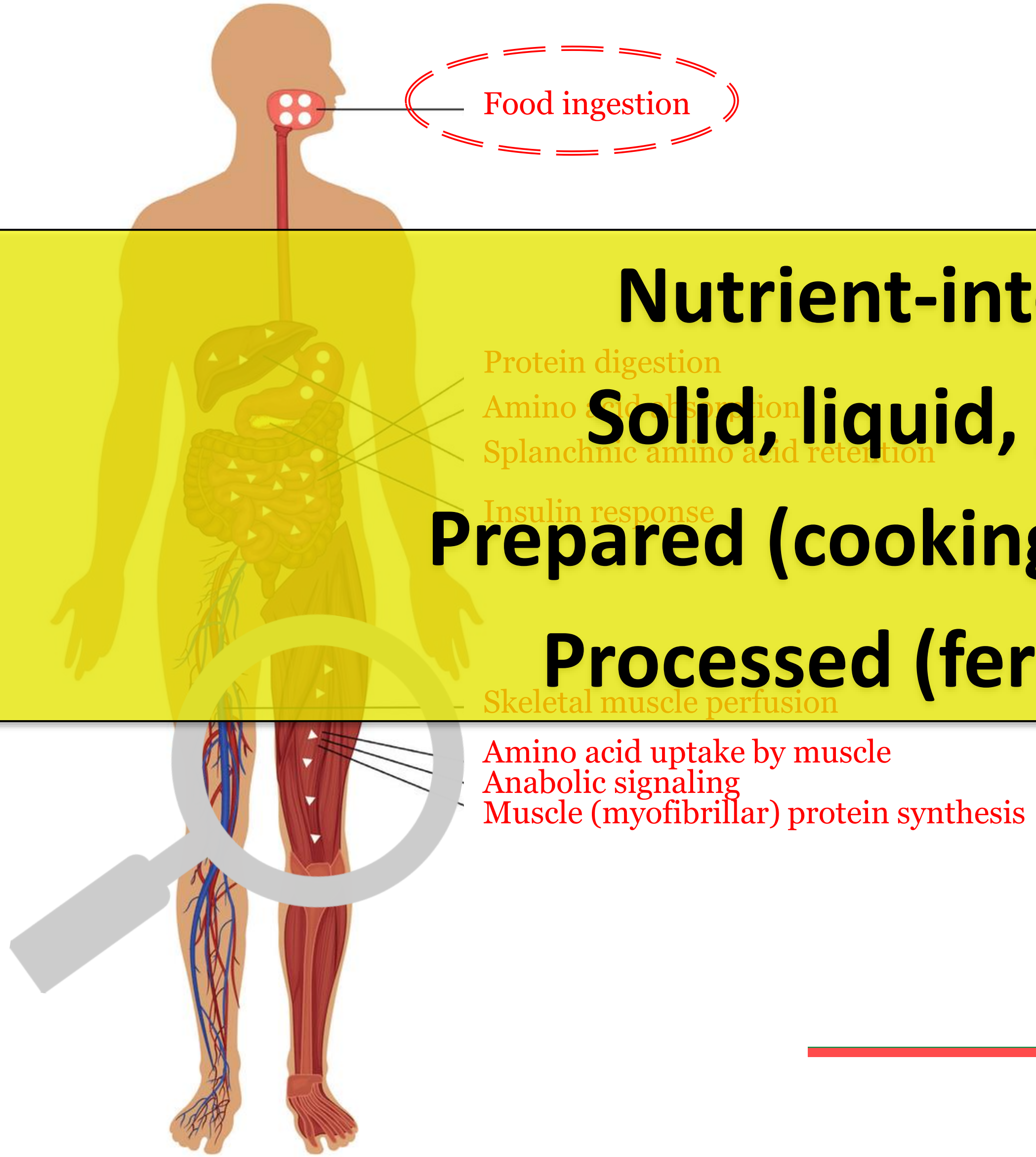




Tang et al. 2009, J Appl Physiol 107(3): 987-992

Burd et al. 2019, Sports Medicine 49(1): 59-68

But we don't eat protein alone … we eat food!



Nutrient-interactions

Solid, liquid, gel, forms

Prepared (cooking, heating etc.)

Processed (fermentation)

Comparison of postprandial protein handling after **milk** or **beef** ingestion during exercise recovery using intrinsically labelled protein

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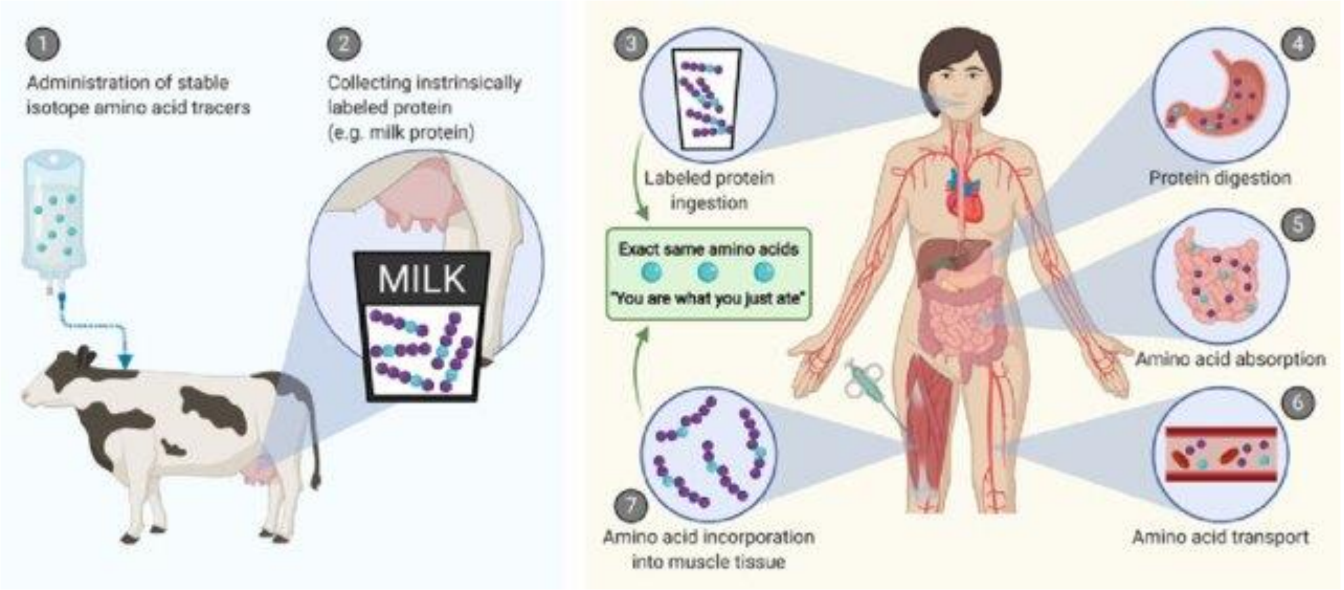
- 12 healthy young (~22 y) males
- Bilateral lower limb resistance exercise
- **350 mL skimmed milk** (247 kcal, 30 g protein, 2.7 g leucine, <1 g fat, 31 g carbohydrate)
- **158 g minced (and grilled) beef patty** (164 kcal, 30 g protein, 2.5 g leucine, 5 g fat, <1 g carbohydrate)
- Amino acid utilization from ingested protein during exercise recovery
- Protein digestion, amino acid absorption, postprandial amino acid availability and MPS



Burd et al. 2015, Am J Clin Nutr 102: 828-836

Trommelen et al. 2021, Proceedings of The Nutrition Society 80(2): 1-9

Skimmed milk ingestion stimulates a greater response of MPS during exercise recovery vs. minced beef

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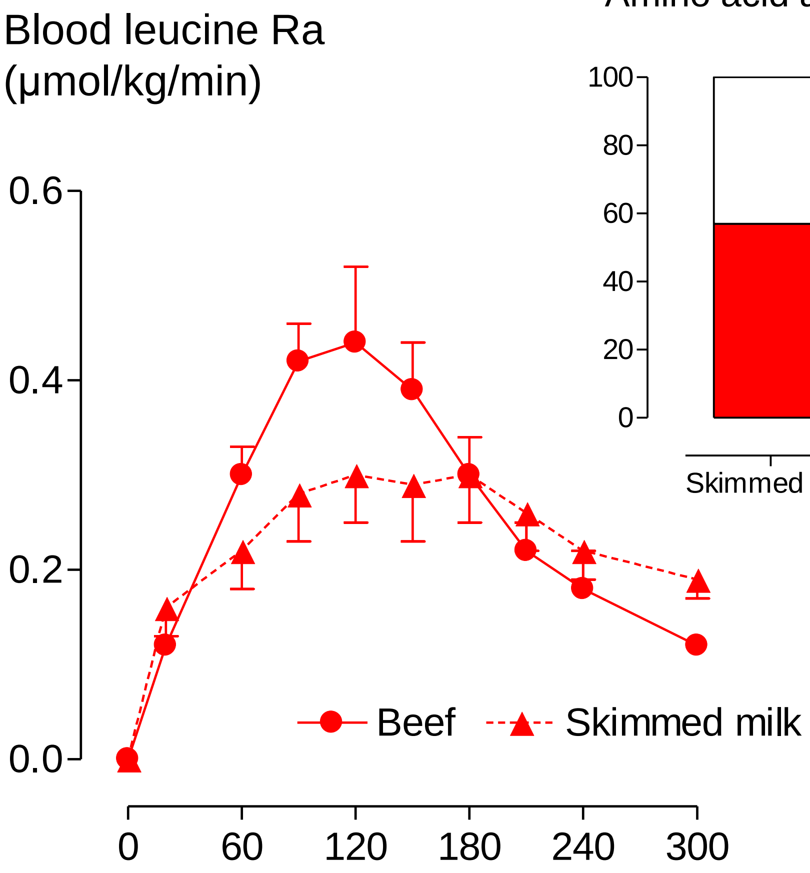
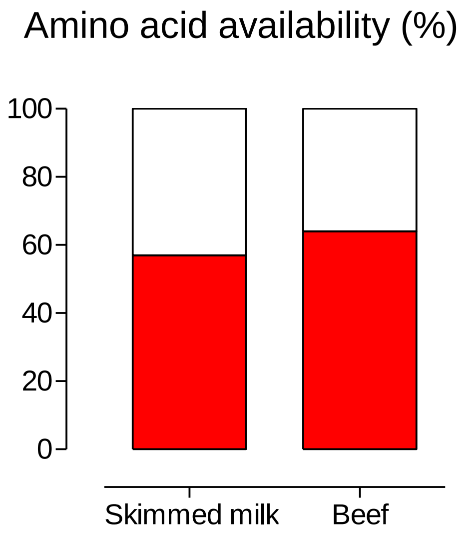
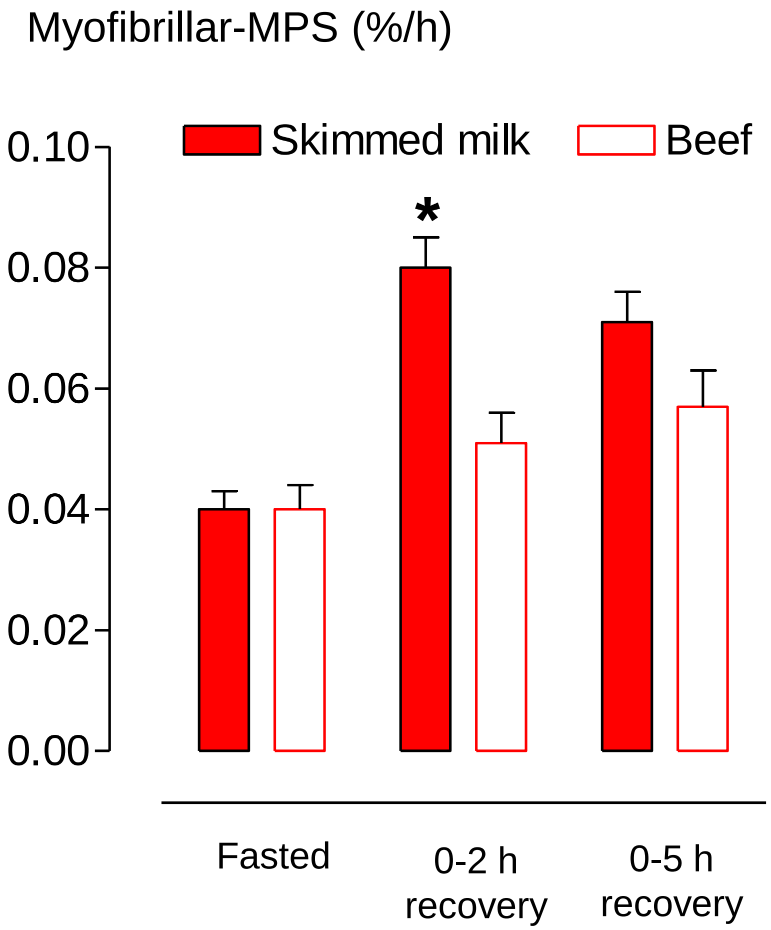
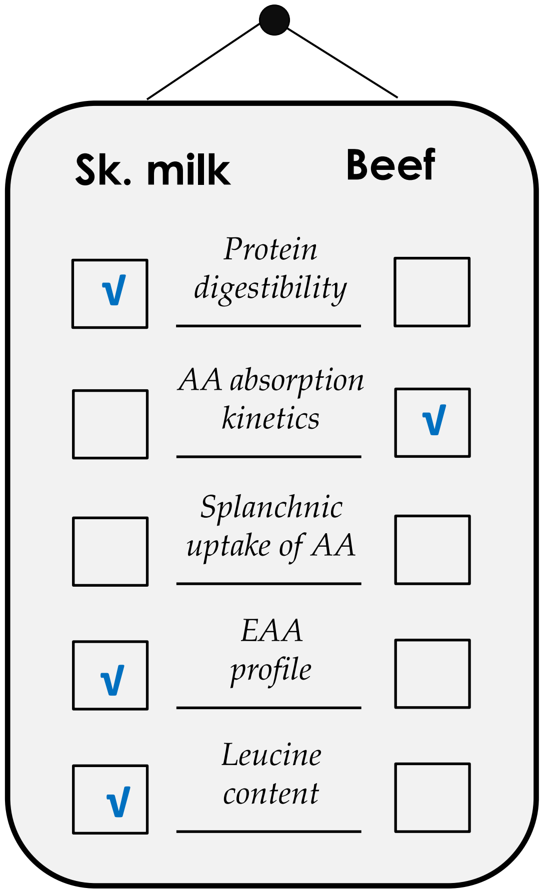




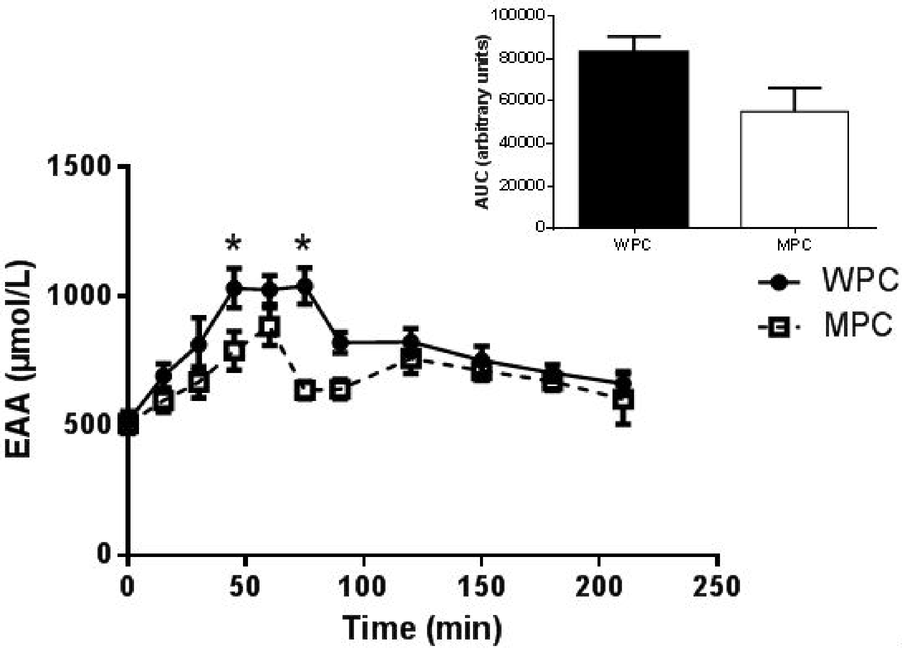


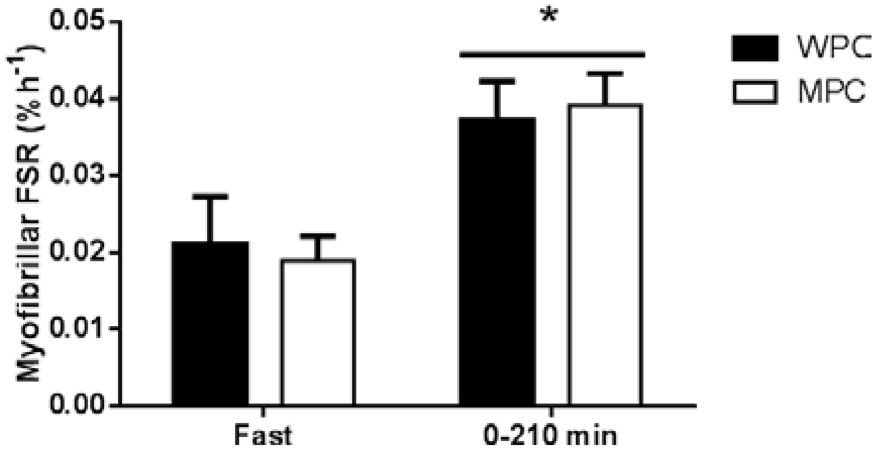


Burd et al. 2015, Am J Clin Nutr 102: 828-836

Milk ingestion stimulates a comparable increase in MPS than whey protein in middle-aged men

- 16 healthy middle-aged (~52 y) men
- 20 g milk protein concentrate
- 20 g whey protein concentrate
- Postprandial amino acid availability and MPS





Mitchell et al. 2014, Nutrients 7: 8685-8699

THE MATRIX effect

"The interactions of nutrient (e.g., protein, vitamins, etc) and non-nutrient components (e.g., physical structure and processing) of food"

Turgeon & Rioux 2011 Food Hydrocolloids 25(8): 1915-1924

The dairy matrix

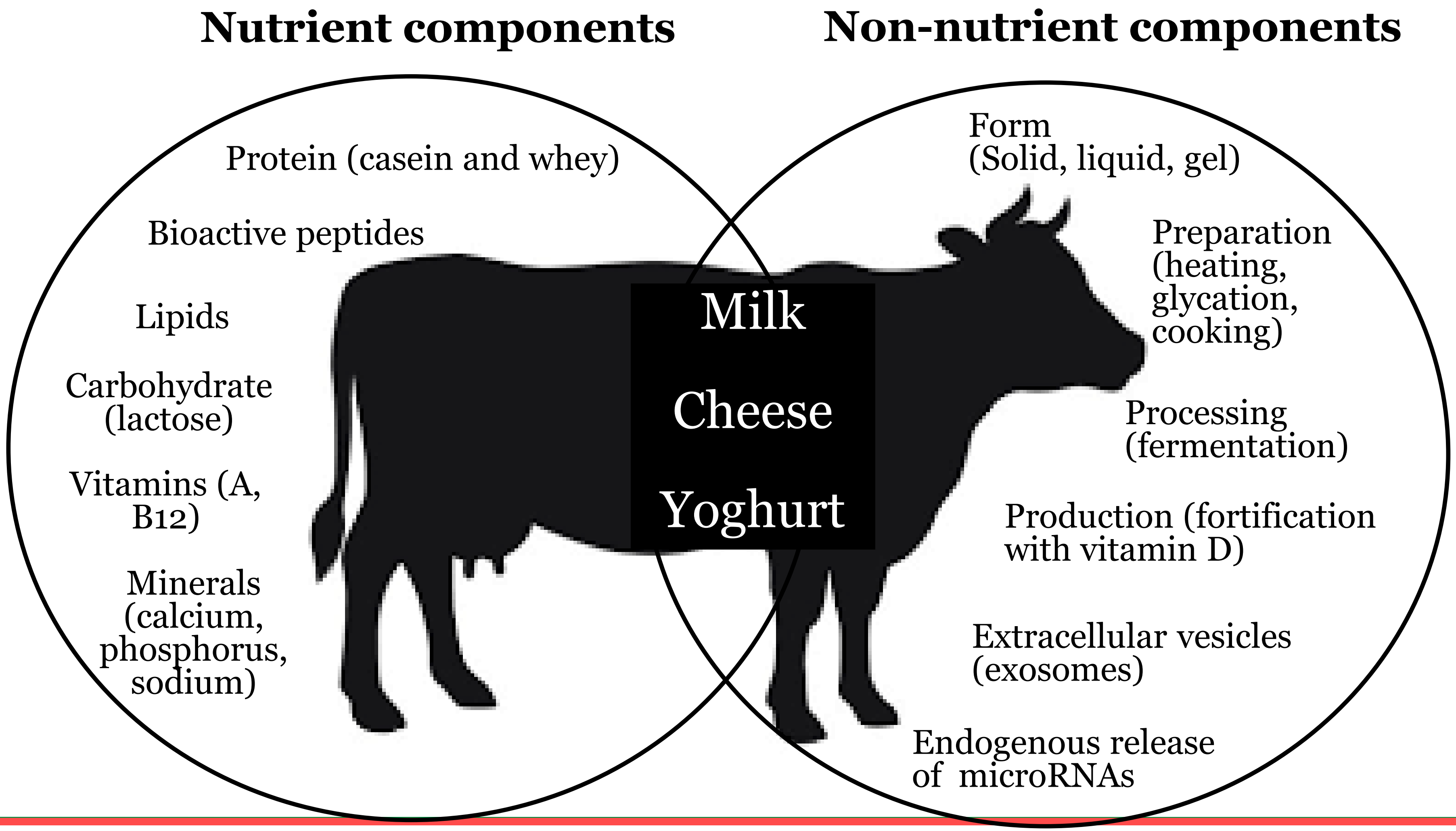


Figure adapted from Geiker et al. 2020, Osteoporosis International 31: 601-615

Whole milk ingestion results in the greater utilization of ingested amino acids during exercise recovery compared with **skimmed milk**

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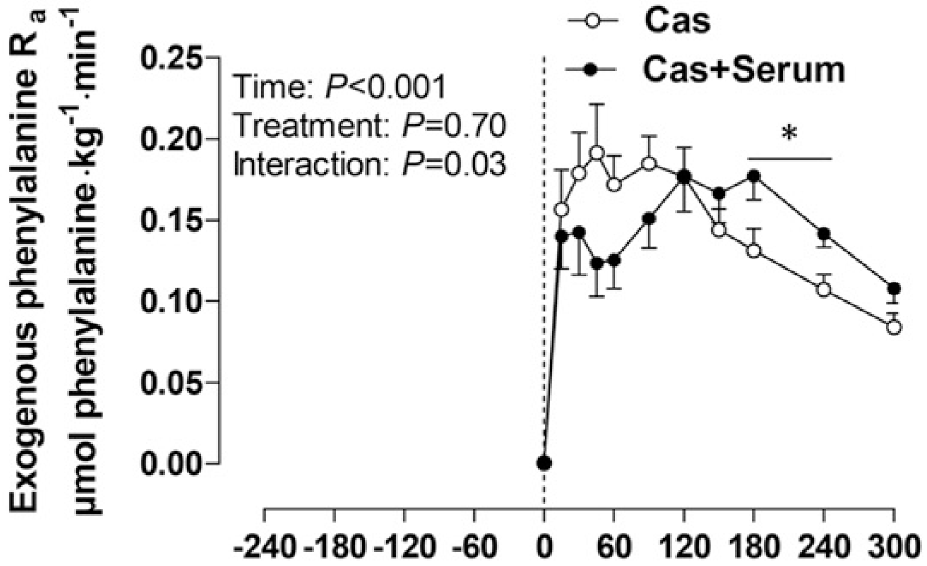
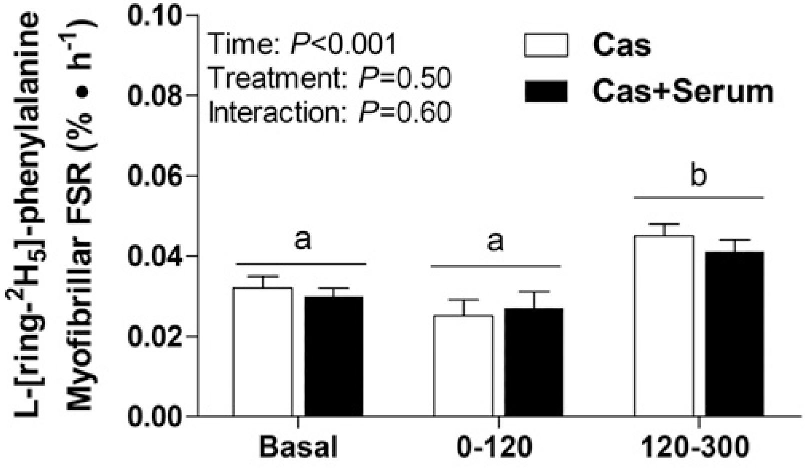
- Healthy young (~24 y) untrained males (n=16) and females (n=8)
- Bilateral lower limb resistance exercise
- **Skimmed milk** (377 kcal, 8.8 g protein, 0.6 g fat, 12 g carbohydrate)
- **Whole milk** (627 kcal, 8.0 g protein, 8.2 g fat, 12 g carbohydrate)
- **Skimmed milk*** (626 kcal, 14.5 g protein, 1.0 g fat, 20 g carbohydrate)
- Amino acid utilization from ingested protein during exercise recovery

Elliot et al. 2006, Medicine & Science in Sport and Exercise 38(4): 667-74

Ingestion of casein in a milk matrix modulates dietary protein digestion and absorption kinetics but does not modulate postprandial MPS in older men

- 32 healthy older (~65 y) adults
- 25 g casein dissolved in bovine milk serum
- 25 g casein dissolved in water
- Amino acid utilization from ingested protein during exercise recovery
- Protein digestion, amino acid absorption, and postprandial MPS

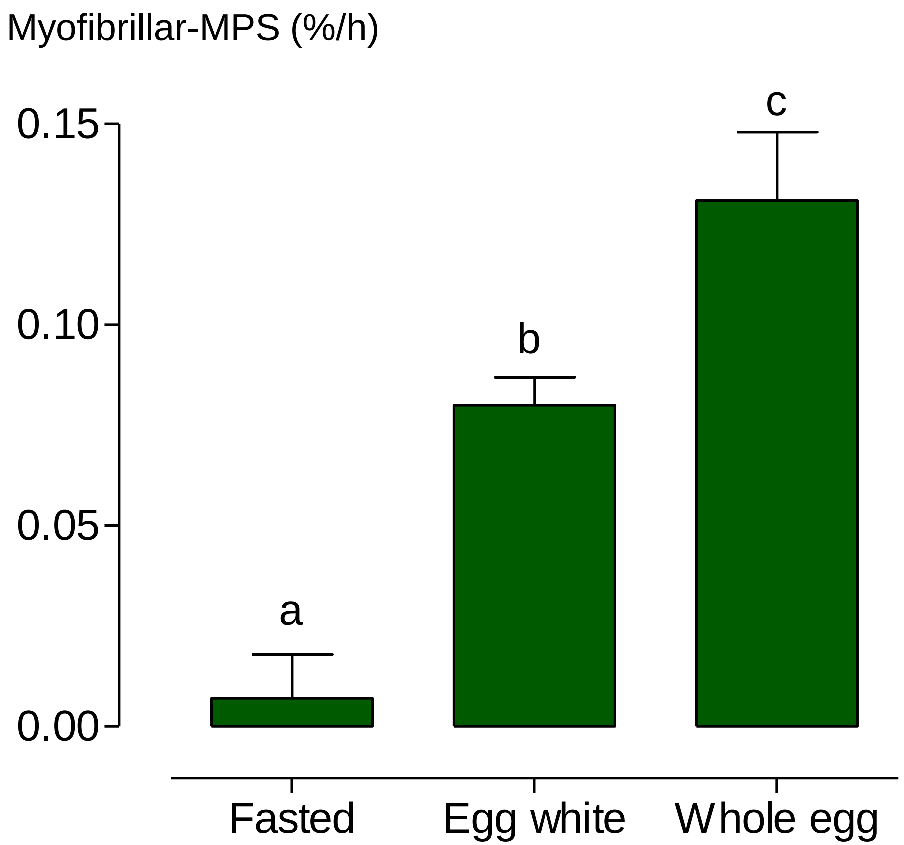




Churchward-Venne et al. 2015, J Nutr 145: 1438-1445

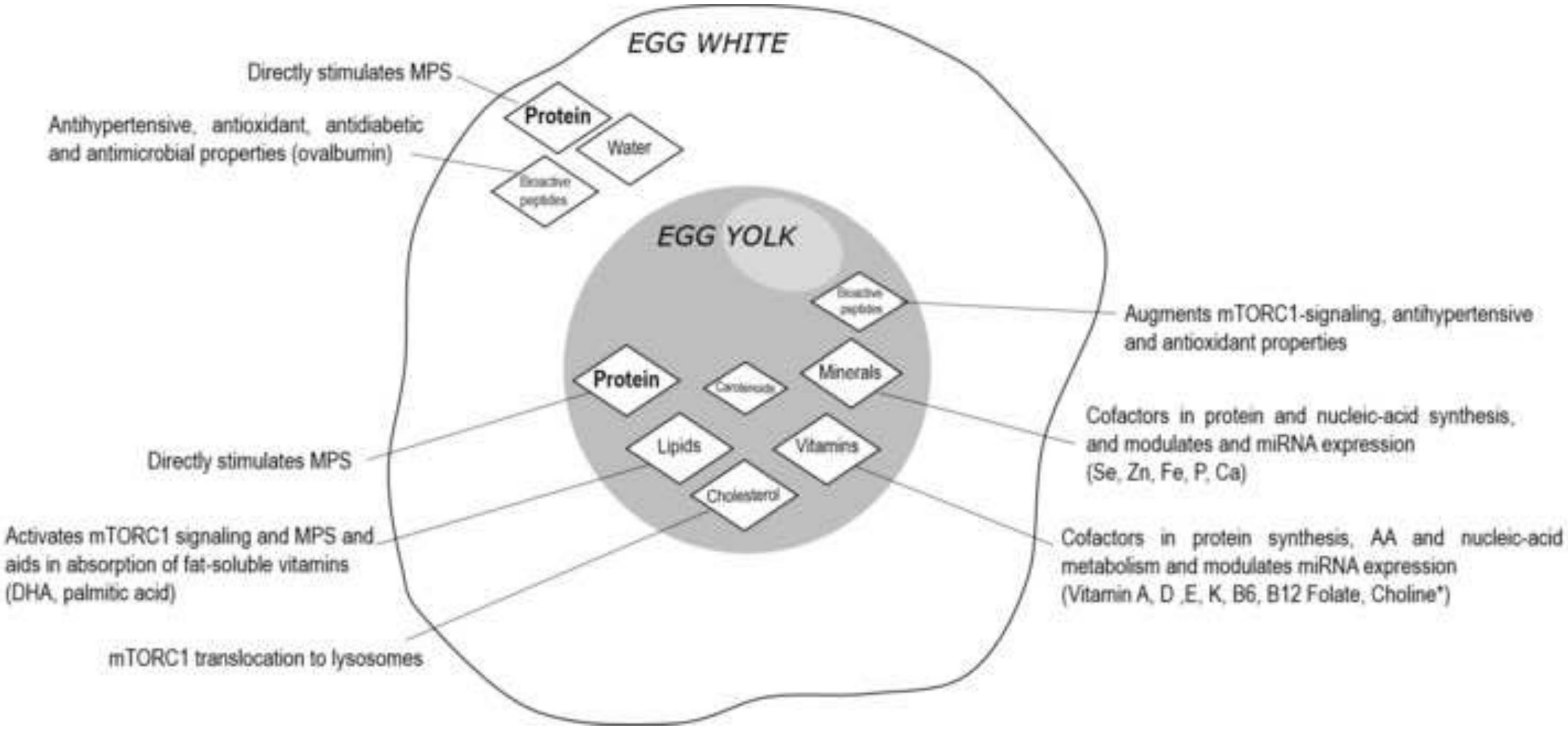
Whole egg ingestion promotes a greater stimulation of MPS than egg white during exercise recovery

- 10 resistance-trained young (~21 y) males
- Bilateral lower limb resistance exercise
- 3 **whole eggs** (226 kcal, 18 g protein, 1.6 g leu, 17 g fat)
- **Egg whites** (18 g protein, 1.6 g leu, 0 g fat)
- Amino acid utilization from ingested protein during exercise recovery
- Protein digestion, amino acid absorption, postprandial amino acid availability and MPS



Van Vliet et al. 2017, Am J Clin Nutr 106(6): 1401-1412

Non-protein components of the whole egg, primarily contained in the yolk, may have a role in regulating MPS



Burd et al. 2019, Sports Medicine 49(1): 59-68

The dairy matrix

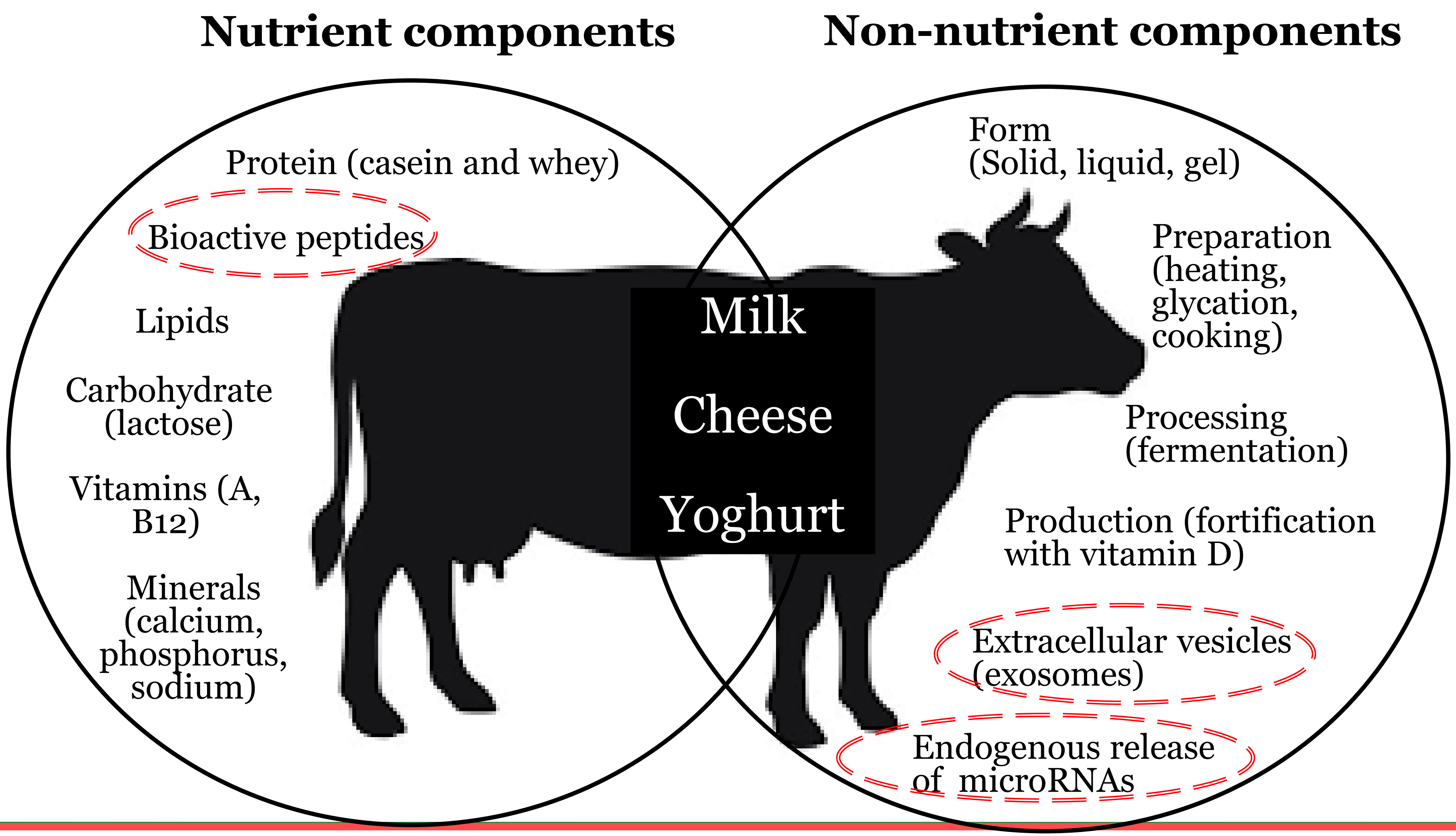
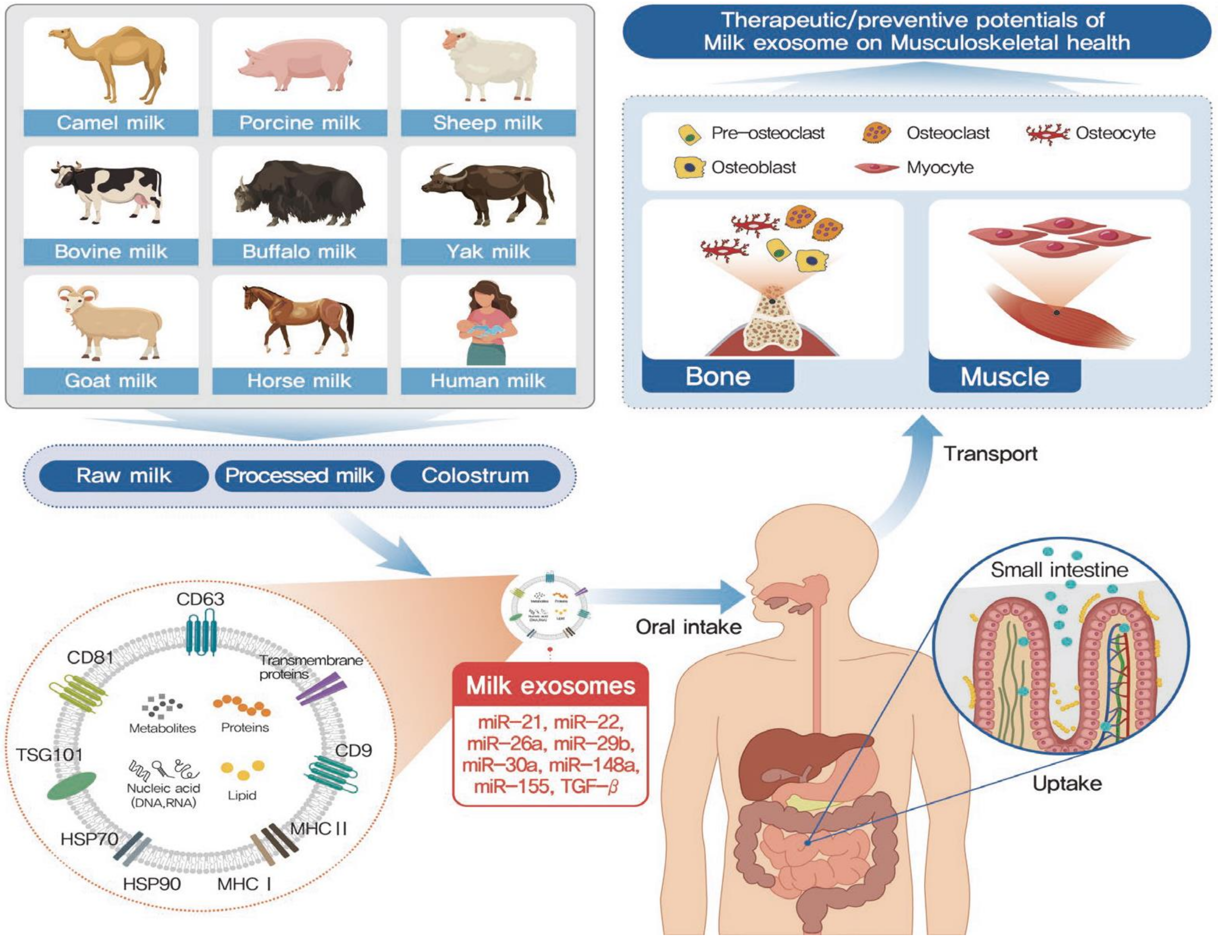


Figure adapted from Geiker et al. 2020, Osteoporosis International 31: 601-615

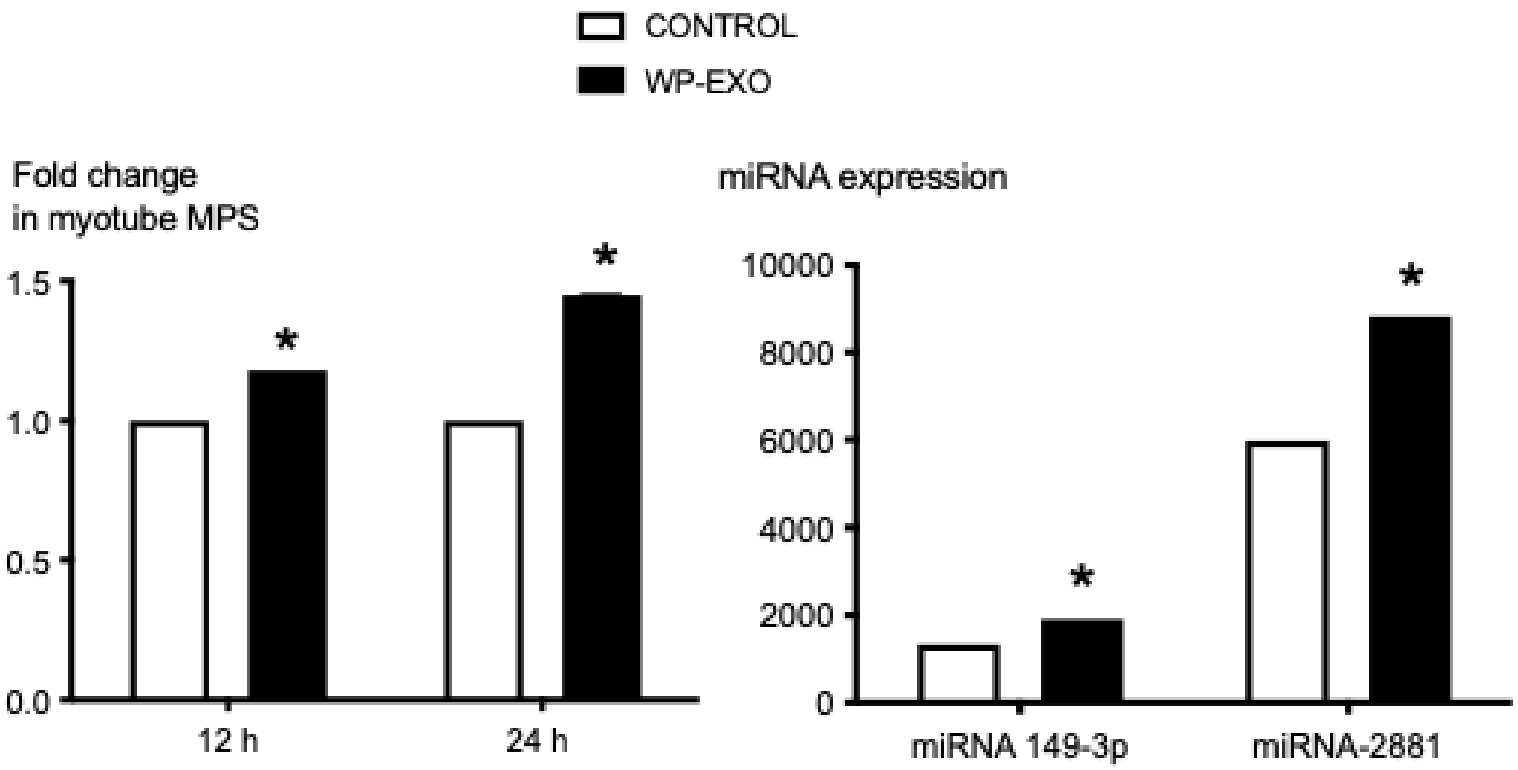
Milk exosomes via release of microRNA's and/or presence of bioactive peptides after milk ingestion may upregulate postprandial MPS



Kim et al. 2023, Nutrients 15: 4645

Whey protein-derived exosomes increase MPS in C_2C_{12} myotubes, as mediated by an increased miRNA expression

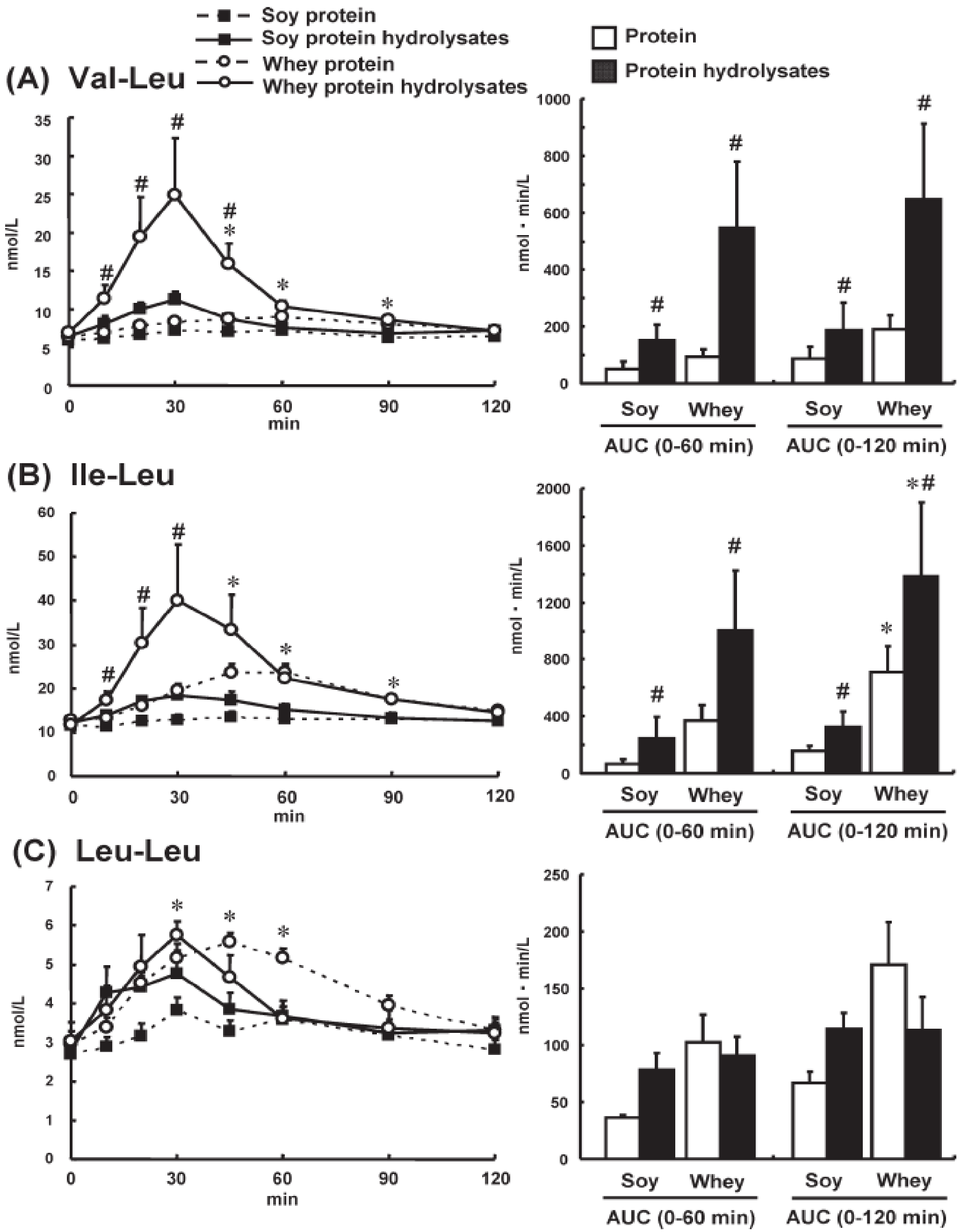
- C_2C_{12} myotubes
- Exosomes isolated from whey protein
- Control (untreated myotubes)
- Myotube diameter, MPS, mTOR signalling, and miRNA expression
- Measured 6, 12 and 24 h post treatment



Mobley et al. 2016, J Dairy Sci 100: 48-64

Whey protein ingestion elicits a greater postprandial appearance of di-/tri-peptides in the circulation than soy protein ingestion

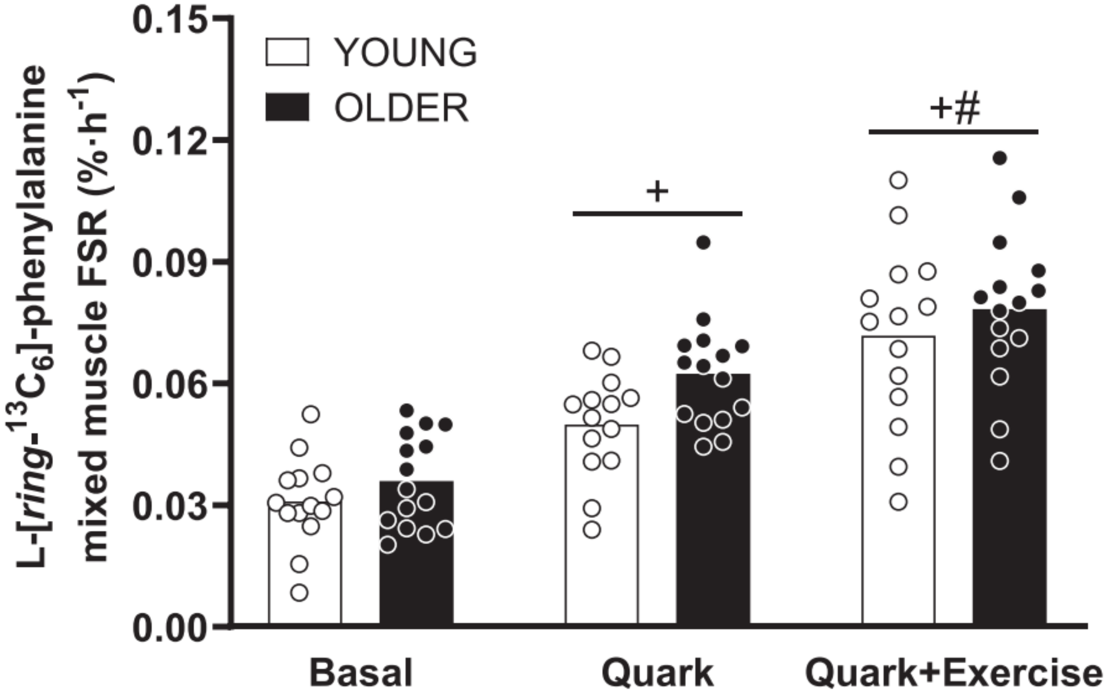
- Middle-aged (n=10) males and females
- 12.5 g of soy protein, soy protein hydrolysate, whey protein or whey protein hydrolysate
- Plasma di-/tri-peptide concentrations



Morifuji et al. 2010, J Agric Food Chem 11:58(15): 8788-97

Quark ingestion stimulates a robust increase in MPS under rested and post-exercise conditions

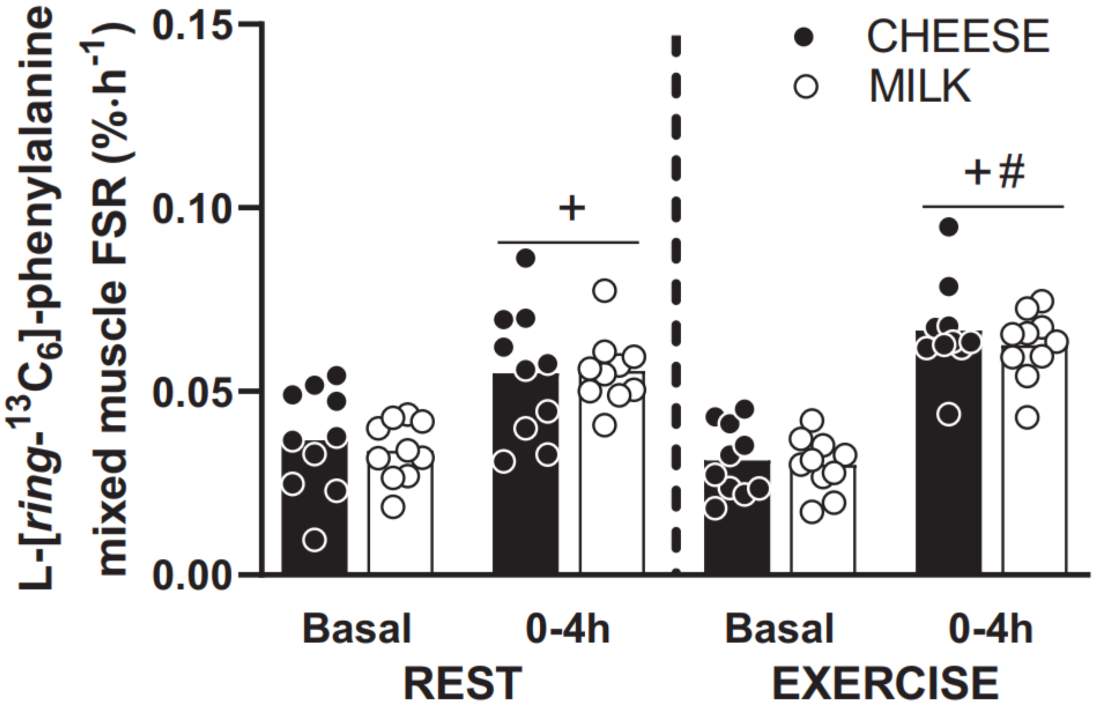
- 14 young (~24 y) and 15 (~73 y) older adults
- Unilateral lower limb resistance exercise
- 291 g **quark** (166 kcal, 30 g protein, 2.9 g leu, 8.2 g carbohydrate, 0.3 g fat)
- Postabsorptive and postprandial mixed MPS at rest and post-exercise



Hermans et al. 2023, J Nutr 155(1): 66-75

Cheese ingestion stimulates MPS to a similar extent as **milk protein concentrate**

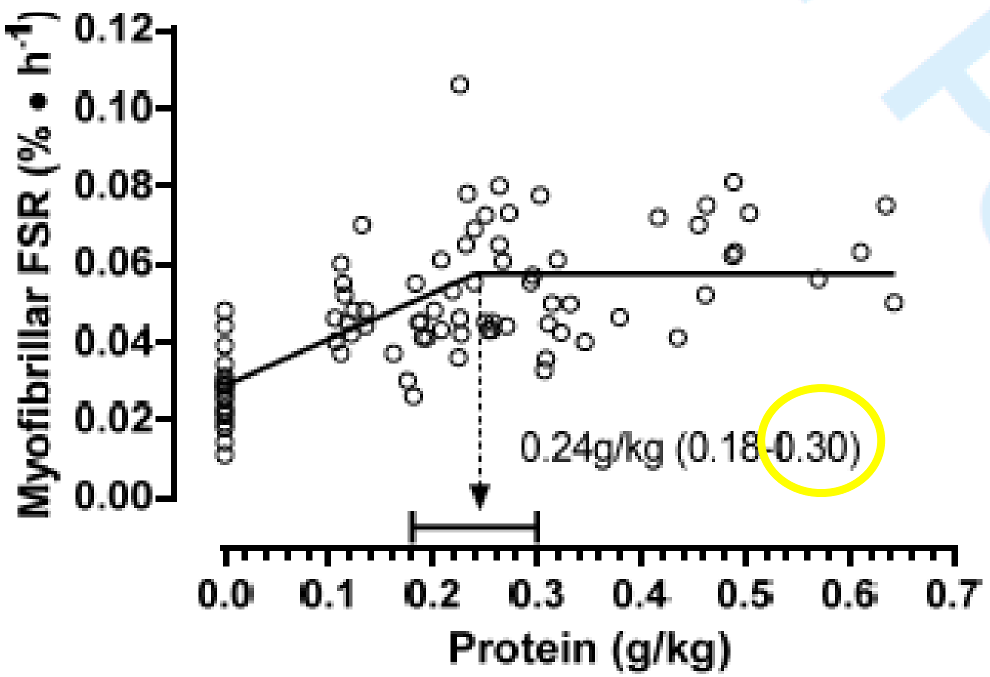
- 20 healthy males (~25 y)
- Unilateral lower limb resistance exercise
- 103 g **cheese** (292 kcal, 30 g protein, 2.4 g leu, 19 g fat)
- 37 g **milk** protein concentrate (142 kcal, 30 g protein, 2.6 g leu, 1 g fat, 2 g carbohydrate)
- Postabsorptive and postprandial mixed MPS at rest and post-exercise



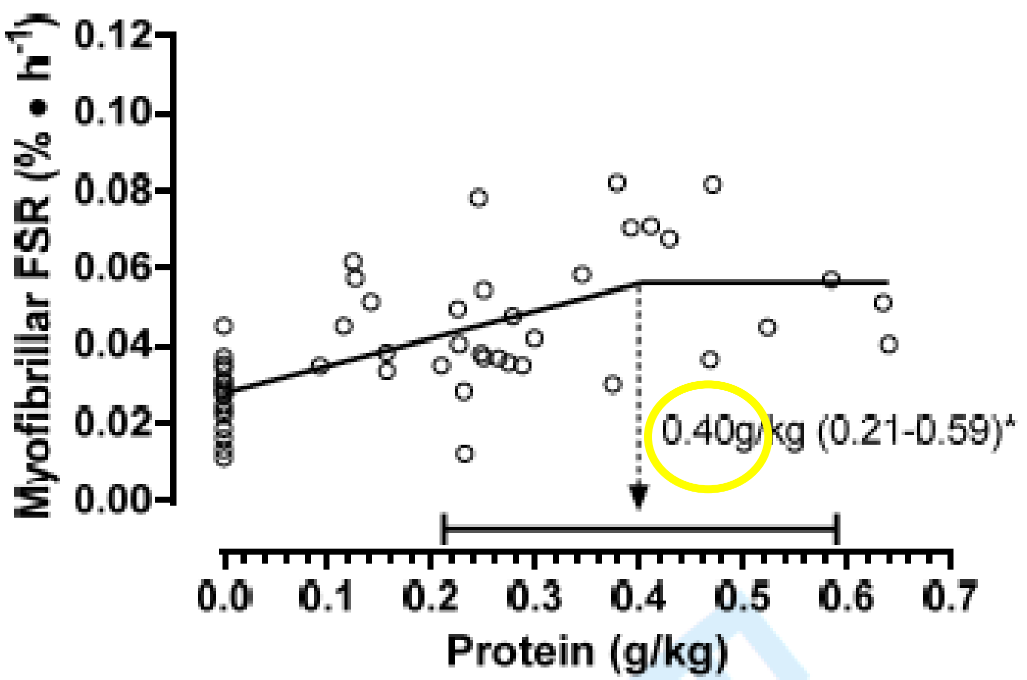
Hermans et al. 2022, J Nutr 152: 1022-1030

>80% of the studies used to inform protein recommendations in young and older adults were conducted with dairy as the "test" protein source

Young (18-35 years) men



Older (>65 years) men



Moore, Witard *et al* 2015 J Gerontology 70(1):57-62

Concluding statements

1. A dairy matrix effect exists with regards to regulating the postprandial stimulation of muscle protein synthesis, meaning we must look beyond protein nutrition with regards to optimizing musculoskeletal health

2. The ingestion of whole dairy foods, and the associated (non)nutrient-nutrient interactions, facilitate a greater MPS response than the individual actions from each individual food component (or sum of its parts!)

3. Should we, as nutrition professionals, redefine protein recommendations to account for the food matrix effect?

Acknowledgements

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Many others …

Many others …

Thank you!