

Appendices

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Appendix A. Methods

Search Strategy and Data Sources

Search Details and Sources

The search strategy was designed and conducted by an experienced systematic review Librarian with input from the investigators. Another Librarian peer reviewed the draft MEDLINE search strategy using the PRESS Checklist. The MEDLINE search included a combination of relevant keywords and MeSH search terms, the search was translated in each database's specified controlled vocabulary. To find additional relevant studies, included studies from relevant systematic reviews were manually screened. We applied the following limits or filters to the database searches:

- Date. Investigators considered a literature search starting in 2000 sufficient for the purpose of this review.
- Language. Publications were excluded if they were written in a language other than English. This was due to resource constraints.
- Publication status. We searched for published studies.
- Human or organism. The search was limited to human studies.
- Study design. The search was restricted to randomized controlled trials and observational cohort studies.
- Filters. For Embase (Ovid), we created a modified filter based on a EMBASE RCT filter for Ovid. Reference: ISSG Search Filter Resource [Internet]. Glanville J, Lefebvre C, Manson P, Robinson S, Brbre I and Woods L, editors. York (UK): The InterTASC Information Specialists' Sub-Group; 2006 [updated 18 February 2024; cited 18 February 2024]. Available from <https://sites.google.com/a/york.ac.uk/issg-search-filters-resource/home>
- Filters. For Scopus, we created a modified RCT filter based on a CADTH search filter All Clinical Trials - Scopus. Reference: CADTH Search Filters Database. Ottawa: CADTH; 2023: <https://searchfilters.cadth.ca/link/106>. Accessed 2023-12-05.
- Filters: We created a modified filter based on a CADTH search filter to remove Embase and MEDLINE records in Scopus. Reference: Scopus NOT Medline/PubMed NOT Embase - Scopus. In: CADTH Search Filters Database. Ottawa: CADTH; 2024: <https://searchfilters.cadth.ca/link/97>. Accessed 2024-03-08. (<https://searchfilters.cadth.ca/link/97>)

We conducted a comprehensive literature search in May 2023, January 2024, and March 2024. We searched the following databases:

- MEDLINE (Ovid) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily Date searched May 31, 2023, January 17, 2024, and March 26, 2024
- Embase (Ovid) Date searched: May 31, 2023, January 17, 2024, and March 26, 2024
- Agricola (Ovid) Date searched: May 31, 2023, January 17, 2024, and March 26, 2024
- Scopus (Elsevier) Date searched: May 31, 2023, January 17, 2024, and March 26, 2024

Ovid MEDLINE(R) ALL <1946 to March 26, 2024>

- 1 animal proteins, dietary/ or dietary proteins/ or egg proteins, dietary/ or fish proteins, dietary/ or fruit proteins/ or grain proteins/ or meat proteins/ or milk proteins/ or nut proteins/ or plant proteins, dietary/ or pea proteins/ or poultry proteins/ or shellfish proteins/ or Soybean Proteins/ or whey proteins/ or Diet, High-Protein/ or diet, high-protein low-carbohydrate/ or (protein? adj3 (ate or animal? or bean? or beef or cheese? or consume* or consumption or content or dairy or diet* or eat or eating or egg? or fish or food or foods or fruit? or goat or grain? or high or increase* or intake* or lacto-vegetarian or lamb or legume? or lentils or macronutrient? or meat? or milk or miso or nut? or nutrition* or nutrient* or pea or peas or pescatarian or pescavegan or plant? or poultry or pork or recommend* or seed? or shellfish? or soy? or soybean? or supplement* or tofu or tempeh or veal or vegan or vegetable? or vegetarian or whey or yog?urt or yolk?)).ti,ab.
- 2 "Bone and Bones"/ or Bone Density/ or bone diseases/ or bone diseases, metabolic/ or bone demineralization, pathologic/ or bone resorption/ or Fractures, Bone/ or (bone disease? or bone densit* or bone demineralization or bone health or bone mass or bone mineral or bone resorption or bone fracture* or osteoporosis or osteopenia).ti,ab.
- 3 kidney calculi/ or Kidney Diseases/ or kidney failure, chronic/ or nephrolithiasis/ or renal insufficiency/ or renal insufficiency, chronic/ or ureterolithiasis/ or ureteral calculi/ or (chronic kidney failure or kidney calculi or kidney disease? or kidney function or kidney insufficiency or kidney stone? or nephrolithiasis or ureteral calculi or ureteral stone? or ureterolithiasis or renal calculi or renal disease? or renal function or renal insufficiency).ti,ab.
- 4 Muscular Atrophy/ or exp Muscle Strength/ or Muscle Weakness/ or sarcopenia/ or (muscle adj3 (atrophy or loss or mass or strength or wasting or weak* or sarcopenia)).ti,ab.
- 5 or/2-4
- 6 1 and 5
- 7 (randomized controlled trial or controlled clinical trial).pt. or randomi?ed.ti,ab. or placebo.ti,ab. or randomly.ab. or trial.ab. or groups.ab.
- 8 allocated.ti,ab,hw.
- 9 ((singl* or doubl* or triple) adj (blind* or dumm* or mask*)).ti,ab,hw,kf.
- 10 ((equivalence or superiority or non-inferiority or noninferiority) adj3 (study or studies or trial*)).ti,ab,hw,kf.
- 11 (Nonrandom* or non random* or non-random* or quasi-random* or quasirandom*).ti,ab,hw,kf.
- 12 or/7-11
- 13 case-control studies/ or clinical trial/ or cohort studies/ or controlled before-after studies/ or cross-over studies/ or pragmatic clinical trial/ or prospective studies/ or (before-after or between group* or clinical study or clinical trial or crossover design or cross-over design or crossover study or cross-over study or nested case-control* or prospectiv* or quasi-experiment*).mp.
- 14 Cohort analy*.tw.
- 15 (Follow up adj (study or studies)).tw.
- 16 (observational adj (study or studies)).tw.
- 17 or/13-16
- 18 12 or 17
- 19 6 and 18
- 20 limit 19 to (english language and yr="2000 -Current")

- 21 case reports/ or comment/ or editorial/ or letter/
- 22 20 not 21
- 23 Animals/ not (Animals/ and Humans/)
- 24 22 not 23

Embase <1974 to 2024 March 26>

- 1 animal protein/ or avian protein/ or fish protein/ or meat protein/ or milk protein/ or pea protein/ or plant protein/ or protein diet/ or protein intake/ or shellfish protein/ or soybean protein/ or whey protein/ or high-protein low-carbohydrate diet/ or (protein? adj3 (ate or animal? or bean? or beef or cheese? or consume* or consumption or content or dairy or diet* or eat or eating or egg? or fish or food or foods or fruit? or goat or grain? or high or increase* or intake* or lacto-vegetarian or lamb or legume? or lentils or macronutrient? or meat? or milk or miso or nut? or nutrition* or nutrient* or pea or peas or pescatarian or pescavegan or plant? or pork or poultry or recommend* or seed? or shellfish? or soy? or soybean? or supplement* or tofu or tempeh or veal or vegan or vegetable? or vegetarian or whey or yog?urt or yolk?)).ti,ab.
- 2 bone/ or bone density/ or bone disease/ or demineralization/ or fracture/ or metabolic bone disease/ or osteolysis/ or (bone disease? or bone densit* or bone demineralization or bone health or bone mass or bone mineral or bone resorption or bone fracture* or osteolysis or osteoporosis or osteopenia).ti,ab.
- 3 kidney disease/ or "chronic kidney disease-mineral and bone disorder"/ or exp chronic kidney failure/ or nephrolithiasis/ or ureter stone/ or urolithiasis/ or (kidney disease? or kidney function or kidney insufficiency or kidney stone? or nephrolithiasis or ureter* calculi or ureter* stone? or ureterolithiasis or renal calculi or renal disease? or renal function or renal insufficiency).ti,ab.
- 4 muscle atrophy/ or muscle function/ or muscle strength/ or muscle weakness/ or sarcopenia/ or (muscle adj3 (atrophy or loss or mass or strength or wasting or weak*)).ti,ab. or sarcopenia.ti,ab.
- 5 or/2-4
- 6 1 and 5
- 7 controlled clinical trial/ or intermethod comparison/ or exp randomized controlled trial/ or randomization/ or (placebo or random*).ti,ab.
- 8 (compare or compared or comparison).ti.
- 9 ((evaluated or evaluate or evaluating or assessed or assess) and (compare or compared or comparing or comparison)).ab.
- 10 ((open adj label) or ((double or single or doubly or singly) adj (blind or blinded or blindly))).ti,ab. or double blind procedure/ or parallel group\$1.ti,ab. or (crossover or cross over).ti,ab. or ((assign* or match or matched or allocation) adj5 (alternate or group? or intervention* or patient? or subject? or participant?)).ti,ab.
- 11 (assigned or allocated or (controlled adj7 (study or design or trial))).ti,ab.
- 12 human experiment/ or trial.ti.
- 13 or/7-12
- 14 6 and 13
- 15 case control study/ or clinical trial/ or clinical trial/ or cohort analysis/ or crossover procedure/ or pragmatic trial/ or (before-after or between group* or crossover design or cross over design or crossover procedure or crossover study or cross over study or nested case-control* or prospectiv* or quasi-experiment*).ti,ab.

- 16 Cohort analy*.tw.
- 17 (Follow up adj (study or studies)).tw.
- 18 (observational adj (study or studies)).tw.
- 19 or/15-18
- 20 13 or 19
- 21 6 and 20
- 22 ((rat or rats or mouse or mice or swine or porcine or murine or sheep or lambs or pigs or piglets or rabbit or rabbits or cat or cats or dog or dogs or cattle or bovine or monkey or monkeys).ti. and animal experiment/) or (Animal experiment/ not (human experiment/ or human/))
- 23 21 not 22
- 24 limit 23 to (english language and yr="2000 -Current")
- 25 (Book or Chapter or Conference Abstract or Conference Paper or Conference Review or Preprint).pt. or book/ or case report/ or editorial/ or letter/ or note/
- 26 24 not 25

AGRICOLA <1970 to March 2024>

- 1 animal source protein/ or dairy protein/ or egg source protein/ or high protein foods/ or legume protein/ or meat protein/ or exp high protein diet/ or exp plant source protein/ or soy protein/ or textured proteins/ or (protein? adj3 (ate or animal? or bean? or beef or consume* or consumption or content or dairy or diet* or eat or eating or egg? or fish or food or foods or fruit? or goat or grain? or high or increase* or intake* or lacto-vegetarian or lamb or legume? or lentil? or macronutrient? or meat? or milk or nut? or nutrition* or nutrient* or pea or peas or pescatarian or pescavegan or plant? or poultry or pork or recommend* or seafood or seed? or shellfish or soy? or soybean? or supplement* or tempeh or tofu or veal or vegan or vegetable? or vegetarian or whey or yog?urt or yolk?)).ti,ab.
- 2 bone diseases/ or bone density/ or bone fractures/ or bone health/ or bone resorption/ or osteopenia/ or osteoporosis/ or (bone disease? or bone densit* or bone demineralization or bone health or bone mass or bone resorption or fracture* or osteoporosis or osteopenia).ti,ab.
- 3 kidney diseases/ or renal calculi/ or ureteral calculi/ or (kidney disease? or kidney function or kidney stone? or nephrolithiasis or ureteral calculi or ureteral stone? or ureterolithiasis or renal calculi or renal disease? or renal function or renal insufficiency).ti,ab.
- 4 muscular atrophy/ or muscle strength/ or hand strength/ or sarcopenia/ or (muscle adj3 (atrophy or loss or mass or strength or wasting or weak* or sarcopenia)).ti,ab.
- 5 or/2-4
- 6 1 and 5
- 7 limit 6 to (english language and yr="2000 -Current")
- 8 clinical trials/ or cross-over studies/ or randomized clinical trials/ or (cross-over study or nonrandom* or non random* or non-random* or quasi-random* or quasirandom* or random* or placebo or trial or groups).ti,ab,hw.
- 9 allocated.ti,ab,hw.
- 10 ((singl* or doubl*) adj (blind* or dumm* or mask*)).ti,ab,hw.
- 11 ((equivalence or superiority or non-inferiority or noninferiority) adj3 (study or studies or trial*)).ti,ab,hw.
- 12 case-control studies/ or cohort studies/ or observational studies/ or prospective studies/
- 13 (observational adj (study or studies)).tw.

- 14 (Follow up adj (study or studies)).tw.
- 15 Cohort analy*.tw.
- 16 or/8-15
- 17 7 and 16
- 18 exp human nutrition/ or exp people/
- 19 17 and 18

Scopus (Elsevier)

((INDEXTERMS ("Muscular Atrophy") OR INDEXTERMS ("Muscle Strength") OR INDEXTERMS ("Muscle Weakness") OR INDEXTERMS (sarcopenia) OR TITLE-ABS ((muscle OR muscular) W/3 (atrophy OR loss OR mass OR strength OR wasting OR weak*)) OR TITLE-ABS (sarcopenia)) OR (INDEXTERMS ("kidney calculi") OR INDEXTERMS ("Kidney Diseases") OR INDEXTERMS ("kidney failure, chronic") OR INDEXTERMS (nephrolithiasis) OR INDEXTERMS ("renal insufficiency") OR INDEXTERMS ("renal insufficiency, chronic") OR INDEXTERMS (ureterolithiasis) OR INDEXTERMS ("ureteral calculi") OR TITLE-ABS ("chronic kidney failure" OR "kidney calculi" OR "kidney disease*" OR "kidney function" OR "kidney insufficiency" OR "kidney stone*" OR nephrolithiasis OR "ureteral calculi" OR "ureteral stone*" OR ureterolithiasis OR "renal calculi" OR "renal disease*" OR "renal function" OR "renal insufficiency")) OR (INDEXTERMS ("Bone and Bones") OR INDEXTERMS ("Bone Density") OR INDEXTERMS ("bone diseases") OR INDEXTERMS ("bone diseases, metabolic") OR INDEXTERMS ("bone demineralization, pathologic") OR INDEXTERMS ("bone resorption") OR INDEXTERMS ("Fractures, Bone") OR TITLE-ABS ("bone disease*" OR "bone densit*" OR "bone demineralization" OR "bone health" OR "bone mass" OR "bone mineral" OR "bone resorption" OR "bone fracture*" OR osteoporosis OR osteopenia))) AND (INDEXTERMS ("Dietary Proteins") OR INDEXTERMS ("dairy proteins") OR INDEXTERMS ("egg protein") OR INDEXTERMS ("Diet, High-Protein") OR INDEXTERMS ("diet, high-protein low-carbohydrate") OR INDEXTERMS ("animal protein") OR INDEXTERMS ("soy proteins") OR INDEXTERMS ("plant proteins") OR TITLE-ABS ((protein*) W/3 (ate OR animal* OR bean* OR beef OR beverage* OR cheese OR consume* OR consumption OR content OR dairy OR diet* OR drink* OR eat OR eating OR egg* OR fish OR food OR foods OR fruit* OR goat OR grain* OR high OR increase* OR intake* OR lacto-vegetarian OR lamb OR legumes OR lentils OR macronutrient* OR meat* OR milk OR nut* OR nutrition* OR nutrient* OR pea OR peas OR pescatarian OR pescavegan OR plant* OR pork OR poultry OR recommend* OR seeds OR shellfish OR soy* OR soybean OR supplement* OR tempeh OR tofu OR veal OR vegan OR vegetable* OR vegetarian OR whey OR yogurt OR yolk*))) AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND NOT INDEX (medline) AND NOT (PMID (0* OR 1* OR 2* OR 3* OR 4* OR 5* OR 6* OR 7* OR 8* OR 9*)) AND NOT INDEX (embase)) AND (((INDEXTERMS ("clinical trial") OR INDEXTERMS ("cross-over studies") OR INDEXTERMS ("pragmatic clinical trial") OR INDEXTERMS ("case-control studies") OR INDEXTERMS ("cohort studies") OR INDEXTERMS ("prospective studies") OR INDEXTERMS ("controlled before-after studies") OR TITLE-ABS-KEY (observational W/3 (study OR studies OR design OR analysis OR analyses)) OR TITLE-ABS-KEY (prospective W/7 (study OR studies OR design OR analysis OR

analyses)) OR TITLE-ABS-KEY ("follow up" OR followup W/7 (study OR studies OR design OR analysis OR analyses)) OR TITLE-ABS-KEY (cohort AND analy*) OR TITLE-ABS-KEY (nested AND case AND control*) OR TITLE-ABS-KEY (quasi W/1 (experiment OR experiments OR experimental)) OR TITLE-ABS-KEY (cohort AND analy*) OR (TITLE-ABS-KEY (random* OR sham OR placebo*) OR TITLE-ABS-KEY ((singl* OR doubl*) W/1 (blind* OR dumm* OR mask*)) OR TITLE-ABS-KEY ((tripl* OR trebl*) W/1 (blind* OR dumm* OR mask*)) OR TITLE-ABS-KEY (control* W/3 (study OR studies OR trial* OR group*)) OR TITLE-ABS-KEY (clinical W/3 (study OR studies OR trial*)) OR TITLE-ABS-KEY (nonrandom* OR "non random*" OR non-random* OR quasi-random* OR quasirandom*) OR TITLE-ABS-KEY (phase W/3 (study OR studies OR trial*)) OR TITLE-ABS-KEY ((crossover OR cross-over) W/3 (study OR studies OR trial*)) OR TITLE-ABS-KEY ((multicent* OR multi-cent*) W/3 (study OR studies OR trial*)) OR TITLE-ABS (allocated) OR TITLE-ABS-KEY ("open label" OR open-label) W/5 (study OR studies OR trial*)) OR TITLE-ABS-KEY ((equivalence OR superiority OR non-inferiority OR noninferiority) W/3 (study OR studies OR trial*)) OR TITLE-ABS-KEY ("pragmatic study" OR "pragmatic studies") OR TITLE-ABS-KEY ((pragmatic OR practical) W/3 trial*) OR TITLE-ABS-KEY ((quasiexperimental OR quasi-experimental) W/3 (study OR studies OR trial*)) OR TITLE (trial) OR KEY (trial)) OR (TITLE-ABS-KEY (observational W/3 (study OR studies OR design OR analysis OR analyses)) OR TITLE-ABS-KEY (prospective W/7 (study OR studies OR design OR analysis OR analyses)) OR TITLE-ABS-KEY ("follow up" OR followup W/7 (study OR studies OR design OR analysis OR analyses)) OR TITLE-ABS-KEY (cohort AND analy*) OR TITLE-ABS-KEY (nested AND case AND control*) OR TITLE-ABS-KEY (quasi W/1 (experiment OR experiments OR experimental)) OR TITLE-ABS-KEY (cohort AND analy*)) AND (LIMIT-TO (SRCTYPE, "j")) AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))

Appendix B. References Excluded at Full Text

P= Population

I= Intervention

C=Comparison

O=Outcome

S=Study Design

X= Other Reason

1. Adams KF, Newton KM, Chen C, et al. Soy isoflavones do not modulate circulating insulin-like growth factor concentrations in an older population in an intervention trial. *J Nutr.* 2003;133(5):1316-9. doi: 10.1093/jn/133.5.1316. PMID: 12730416. I
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8. Antonio J, Ellerbroek A, Evans C, et al. High protein consumption in trained women: bad to the bone? *J Int Soc Sports Nutr.* 2018;15:6. doi: 10.1186/s12970-018-0210-6. PMID: 29434529. S

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10. Aoe S, Toba Y, Yamamura J, et al. Controlled trial of the effects of milk basic protein (MBP) supplementation on bone metabolism in healthy adult women. *Biosci Biotechnol Biochem.* 2001 Apr;65(4):913-8. doi: 10.1271/bbb.65.913. PMID: 11388472. X
11. Arjmandi BH, Khalil DA, Smith BJ, et al. Soy protein has a greater effect on bone in postmenopausal women not on hormone replacement therapy, as evidenced by reducing bone resorption and urinary calcium excretion. *J Clin Endocrinol Metab.* 2003;88(3):1048-54. doi: 10.1210/jc.2002-020849. PMID: 12629084. I
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Appendix C. Evidence Tables for All Eligible Studies

Table C1. Evidence table for Bone Disease Randomized Controlled Trials (Adults and Children and Adolescents)

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>PMID: NR Aoyagi 2010¹ Location/Country: Japan HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: RCT (parallel) Funding source: Nonprofit Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 79</p> <p>Intervention: High Protein Experimental: 40 mg MBP Supplement N: 44 % Female: 100% Mean Age (SD): 72 (4) y Race/ Ethnicity: Japanese Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Mean physical activity level (SD): 17.5 (10.3) year-averaged duration of exercise Health status/ Comorbidities: No history of conditions affecting bone metabolism (e.g., ovariectomy, cancer, renal disease or rheumatoid arthritis). Medication use: No current treatment with hormonal preparations (e.g., estrogens) or other drugs (e.g., bisphosphonates) likely to influence bone health. Supplement use: NR</p>	<p>Intervention: High Protein Intended Protein Amount: 40 mg of milk basic protein Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 71.9 (17.8) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Dietary Protein Intake Compliance (%): 88%</p> <p>Protein type/source: Animal; milk basic protein</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Normal Protein Intended Protein Amount: NR Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 74.1 (19.6) g/d Carbohydrate Mean (SD): NR</p>	<p>Intervention: High Protein</p> <p>How protein was administered: Participants drank 1 bottle (50 mL) a day of 40mg milk basic protein (Mainichi Hone Kea MBP® Snow Brand Milk Products Co., Ltd., Shinjuku, Tokyo, Japan)</p> <p>Protein Assessment Method: Baseline protein was determined through a 1-wk retrospective dietary questionnaire</p> <p>Dietary Protein Intake Compliance: Participants kept diaries and returned empty bottles at their monthly laboratory visits.</p> <p>Actual Protein Amount was not calculated, though empty bottles returned by participants were counted and food diaries were kept by participants to ensure compliance with intended treatment.</p>	<p>Bone Turnover Marker (Overall Turnover) - Osteocalcin</p> <p>Measure/Method of Assessment: Blood assays</p> <p>Bone Formation Marker - Bone specific alkaline phosphatase</p> <p>Measure/Method of Assessment: Blood and urine assays</p> <p>Bone Resorption Marker - Urinary excretion of deoxypyridinoline</p> <p>Measure/Method of Assessment: Blood and urine assays</p> <p>Bone Resorption Marker – NTx (N-telopeptides of type I collagen)</p> <p>Measure/Method of Assessment: Blood assay</p> <p>BMD of the Appendicular Skeleton - Bone mineral density (forearm, total)</p> <p>Measure/Method of Assessment: Peripheral DXA, using a bone densitometer ([DTX-200, Osteometer MediTEch, Inc.]).</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	Pregnant or lactating: NA Comparator: Normal Protein N: 35 % Female: 100% Mean Age (SD): 72 (6) y Race/ Ethnicity: Japanese Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Mean physical activity level (SD): 14.5 (9.2) year-averaged duration of exercise Health status/Co-morbidities: No history of conditions affecting bone metabolism (e.g., ovariectomy, cancer, renal disease or rheumatoid arthritis). Medication use: No current treatment with hormonal preparations (e.g., estrogens) or other drugs (e.g., bisphosphonates) likely to influence bone health. Supplement use: NR Pregnant or lactating: NA	Fat Mean (SD): NR Actual Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Dietary Protein Intake Compliance (%): 40% Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 12 months	Comparator: Normal Protein How protein was administered: Participants were instructed to keep their dietary habits the same Protein Assessment Method: Same as above Dietary Protein Intake Compliance: Same as above	
PMID: 15727682 Arjmandi 2005² Location/Country: USA HDI: Very high Setting: Community dwelling	Study of: Adults Total sample N: 62 Intervention: High Protein N: 35 % Female: 100%	Intervention: High Protein Intended Protein Amount: 25 g/d of supplement Carbohydrate: NR Fat: NR	Intervention: High Protein How protein was administered: Participants ate a test food of 25 g soy products	Total Body BMD - Bone mineral density (total body) Measure/Method of Assessment: DXA (Hologic QDR-4500C)

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>Urban/ Rural: NR Study design: RCT (parallel) Funding source: Industry, state agency Risk of bias score: High</p>	<p>Mean Age (SE): 53 (6) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SE): 28.6 (0.9) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Women with cancer, liver disease, hypo- or hyperthyroidism, gastrointestinal disorders, insulin-dependent diabetes mellitus, pelvic inflammatory disease, and endometrial polyps were excluded from the study Medication use: Study participants were not on any prescription medication. Supplement use: Herbal supplement was exclusion criteria Pregnant or lactating: NA</p> <p>Comparator: Normal Protein N: 27 % Female: 100% Mean Age (SE): 56 (5) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SE): 27.3 (1.0) kg/m²</p>	<p>Baseline Protein Amount Mean (SE): 75.8 (3.6) g/d Carbohydrate Mean (SE): 243 (12) g/d Fat Mean (SE): 62.5 (4.1) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SE): 87.3 (3.6) g/d Carbohydrate Mean (SE): 202 (12) g/d Fat Mean (SE): 57.0 (4.2) g/d</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Plant; soy products</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Normal Protein</p> <p>Intended Protein Amount: NR Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SE): 64.2 (4.1) g/d Carbohydrate Mean (SE): 207 (14) g/d Fat Mean (SE): 56.6 (4.8) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SE): 87.8 (4.1) g/d Carbohydrate Mean (SE): 247 (14) g/d Fat Mean (SE): 59.0 (4.8) g/d</p>	<p>(donated by DrSoy Nutrition Irvine, CA) in the form of a snack bar, drink mix, or cereal</p> <p>Protein Assessment Method: Baseline and end-of-study protein was obtained from a 1-wk food frequency questionnaire via interview by a registered dietitian. Actual protein was determined by analysis of customized calendars for participants to record amount of test food consumed.</p> <p>Dietary Protein Intake Compliance: Participants recorded how much of each of the cereal, the snack bar, or the drink mix they consumed on a customized calendar. Participants also returned any unconsumed foods.</p> <p>Comparator: Normal Protein</p> <p>How protein was administered: Participants consumed comparative controls</p> <p>Protein Assessment Method: Same as above</p>	<p>BMD of the Axial Skeleton - Bone mineral density (L1-L4 (lumbar spine))</p> <p>Measure/Method of Assessment: DXA (Hologic QDR-4500C)</p> <p>BMD of the Appendicular Skeleton - Bone mineral density (hip, total)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR-4500C)</p> <p>Total Body BMC - Bone mineral content (total body)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR-4500C)</p> <p>BMC of the Axial Skeleton - Bone mineral content (L1-L4 (lumbar spine))</p> <p>Measure/Method of Assessment: DXA (Hologic QDR-4500C)</p> <p>BMC of the Appendicular Skeleton - Bone mineral content (hip, total)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR-4500C)</p> <p>Bone Turnover Marker (Overall Turnover) - Osteocalcin</p> <p>Measure/Method of Assessment: Blood sample (serum)</p> <p>Bone Formation Marker - Bone specific alkaline phosphatase</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Women with cancer, liver disease, hypo- or hyperthyroidism, gastrointestinal disorders, insulin-dependent diabetes mellitus, pelvic inflammatory disease, and endometrial polyps were excluded from the study Medication use: Study participants were not on any prescription medication. Supplement use: Herbal supplement was exclusion criteria Pregnant or lactating: NA</p>	<p>Dietary Protein Intake Compliance (%): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 1 y</p>	<p>Dietary Protein Intake Compliance: Same as above</p>	<p>Measure/Method of Assessment: Blood sample (serum) Bone Resorption Marker - Urinary excretion of deoxypyridinoline Measure/Method of Assessment: Blood sample (serum)</p>
<p>PMID: 22357739 Bonjour 2012³ Location/Country: France HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: RCT (parallel) Funding source: Industry Risk of bias score: Moderate</p>	<p>Study of: Adults Total sample N: 71 Intervention: Treated group N: 36 % Female: 100% Mean Age (SD): 57.1 (3.9) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 23.1 (2.2) kg/m² Income level: NR Education level: NR Physical activity level: NR</p>	<p>Intervention: Treated group Intended Protein Amount: Test food supplement: 13.8 g protein Carbohydrate: NR Fat: NR Baseline Protein Amount Mean (SD): 72 (17) g/d Carbohydrate Mean (SD): 193 (73) g/d Fat Mean (SD): 79 (19) g/d Actual Protein Amount at the end of the study (change) Mean (SD): 11.4 (18.5) g/d Carbohydrate (change) Mean (SD): -11.3 (61.4) g/d</p>	<p>Intervention: Treated group How protein was administered: Dairy (skimmed-milk, soft, plain cheese fortified with vitamin D and calcium) test food given to participants, 2 servings, 100 g each, once daily. Protein Assessment Method: Baseline protein, intermediary, and post protein amounts were derived from a dietary follow-up questionnaire</p>	<p>Bone Resorption Marker - CTX (carboxy terminal crosslinked telopeptide of type I collagen) Measure/Method of Assessment: Blood sample serum Bone Resorption Marker - TRAP (5b, tartrate resistant acid phosphatase, isoform 5) Measure/Method of Assessment: Blood sample serum Bone Turnover Marker (Overall Turnover) - Osteoclastin Measure/Method of Assessment: Blood sample serum</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Health status/ Comorbidities: Exclusion criteria: disorders influencing calcium-phosphate and/or bone metabolism, such as hyperparathyroidism, Paget disease, or chronic condition requiring cortisone therapy. Medication use: Inclusion criteria: no antiosteoporotic medication, such as bisphosphonates, raloxifen, strontium ranelate, teriparatide, and/or denosumab Supplement use: exclusion criteria: use of calcium and or vitamin D supplement, taken as pharmaceutical preparation or fortified foods, during the preceding 6 months Pregnant or lactating: NA</p> <p>Comparator: Usual diet N: 35 % Female: 100 Mean Age (SD): 56.1 (3.9) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 22.9 (2.5) kg/m² Income level: NR Education level: NR</p>	<p>Fat (change) Mean (SD): 9.4 (24.4) g/d</p> <p>Dietary Protein Intake Compliance (%): 100%</p> <p>Protein type/source: Animal; skimmed-milk, soft, plain cheese</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Usual diet</p> <p>Intended Protein Amount: NR Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 199 (79) g/d Carbohydrate Mean (SD): 199 (79) g/d Fat Mean (SD): 78 (28) g/d</p> <p>Actual Protein Amount at the end of the study (change) Mean (SD): 0.9 (16.5) g/d Carbohydrate (change) Mean (SD): -11.6 (61.4) g/d Fat (change) Mean (SD): 5.5 (22.3) g/d</p> <p>Dietary Protein Intake Compliance (%): 100%</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p>	<p>Dietary Protein Intake Compliance: Participants completed a self-rating diary, which had to be completed every day.</p> <p>Comparator: Usual diet</p> <p>How protein was administered: Participants advised to maintain their usual diet</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	<p>Bone Formation Marker – Bone specific alkaline phosphatase</p> <p>Measure/Method of Assessment: Blood sample serum</p> <p>Bone Formation Marker – P1NP (Procollagen type 1 N-terminal propeptide)</p> <p>Measure/Method of Assessment: Blood sample serum</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	Physical activity level: NR Health status/ Comorbidities: Exclusion criteria: disorders influencing calcium-phosphate and/or bone metabolism, such as hyperparathyroidism, Paget disease, or chronic condition requiring cortisone therapy. Medication use: Inclusion criteria: no antiosteoporotic medication, such as bisphosphonates, raloxifen, strontium ranelate, teriparatide, and/or denosumab Supplement use: exclusion criteria: use of calcium and or vitamin D supplement, taken as pharmaceutical preparation or fortified foods, during the preceding 6 months Pregnant or lactating: NA	Study duration: 6 weeks		
PMID: 24047916 Jesudason 2013 ⁴ Location/Country: Australia HDI: Very high Setting: Community dwelling Urban/Rural: NR Study Design: RCT (parallel) Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 323 Intervention: High Protein N: 164 % Female: 100% Mean Age (SE): 59.5 (0.4) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: Obese	Intervention: High Protein Intended Protein Amount: 32% of energy Carbohydrate: 44% of energy Fat: 24% of energy Baseline Protein Amount Mean (SE): 92.5 (2.2) g/d; 18.6 (0.2) % of energy Carbohydrate Mean (SE): 230 (6) g/d; 42.9 (0.5) % of energy	Intervention: High Protein How protein was administered: Participants received monthly group dietetic education and support for the first 6 months and then every 3 months for the next 18 months. Sample food packs of \$20 vouchers were provided	BMD of the Axial Skeleton - Bone mineral density L2-L4 (lumbar spine vertebra) Measure/Method of Assessment: DXA (Norland XR-800) BMD of the Appendicular Skeleton - Bone mineral density (distal forearm, total) Measure/Method of Assessment: DXA (Norland XR-800)

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Mean BMI (SE): 34.0 (0.4) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Subjects with parathyroid disease, a vitamin D concentration, 60 nmol/L with secondary hyperparathyroidism, or unstable metabolic, cardiac, gastrointestinal, renal, or other significant disease, including malignancies, were excluded Medication use: Women were ineligible if they were taking hormone-replacement therapy, bisphosphonates, steroids, diuretics, calcium, or vitamin D Supplement use: Women were ineligible if they were taking calcium or vitamin D Pregnant or lactating: NA</p> <p>Comparator: Normal Protein N: 159 % Female: 100% Mean Age (SE): 59.4 (0.4) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: Obese</p>	<p>Fat Mean (SE): 79.2 (2.7) g/d; 33.3 (0.4) % of energy</p> <p>Actual Protein Amount at the end of the study Mean (SE): 91.5 (2.2) g/d; 21.9 (0.3) % of energy Carbohydrate Mean (SE): 196 (6) g/d; 43.9 (0.7) % of energy Fat Mean (SE): 55.5 (2.3) g/d; 28.2 (0.7) % of energy</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Comparator: Normal Protein</p> <p>Intended Protein Amount: 22% of energy Carbohydrate: 55% of energy Fat: 23% of energy</p> <p>Baseline Protein Amount Mean (SE): 91.2 (1.9) g/day; 18.4 (0.2) % of energy Carbohydrate Mean (SE): 228 (5) g/day; 42.9 (0.5) % of energy Fat Mean (SE): 77.7 (2.1) g/day; 33.4 (0.4) % of energy</p> <p>Actual Protein Amount at the end of the study Mean (SE): 80.6 (2.2) g/day; 18.9 (0.3) % of energy</p>	<p>to participants at baseline and 12 and 26 weeks. Each diet group was allocated to a protein target that was based on key protein foods as a compliance measure.</p> <p>Protein Assessment Method: Participants recorded dietary intakes using a protein counter and checklist. Protein compliance checklists were collected from each participant at each group session. Subjects also completed a FFQ at baseline and 1 and 2 y.</p> <p>Dietary Protein Intake Compliance: Compliance was assessed by (1) blood urea nitrogen and 24h urine for urea nitrogen excretion (2) allocated to a protein target for each diet group and (3) protein-compliance checklists were collected from each participant at each group session.</p> <p>Comparator: Normal Protein</p> <p>How protein was administered: Participants received monthly group dietetic</p>	<p>BMD of the Appendicular Skeleton - Bone mineral density (hip, total) Measure/Method of Assessment: DXA (Norland XR-800)</p> <p>BMD of the Appendicular Skeleton - Bone mineral density (femoral neck) Measure/Method of Assessment: DXA (Norland XR-800)</p> <p>Bone Resorption Marker - Bone marker (C-terminal telopeptide) Measure/Method of Assessment: Blood assay</p> <p>Bone Turnover Marker (Overall Turnover) - Osteocalcin Measure/Method of Assessment: Blood sample</p> <p>Bone Formation Marker – Bone specific alkaline phosphatase Measure/Method of Assessment: Blood sample</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Mean BMI (SE): 33.4 (0.4) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Subjects with parathyroid disease, a vitamin D concentration, 60 nmol/L with secondary hyperparathyroidism, or unstable metabolic, cardiac, gastrointestinal, renal, or other significant disease, including malignancies, were excluded Medication use: Women were ineligible if they were taking hormone-replacement therapy, bisphosphonates, steroids, diuretics, calcium, or vitamin D Supplement use: Women were ineligible if they were taking calcium or vitamin D Pregnant or lactating: NA</p>	<p>Carbohydrate Mean (SE): 214 (5) g/day; 47.2 (0.6) % of energy Fat Mean (SE): 57.9 (2.5) g/day; 28.6 (0.7) % of energy Protein type/source: Mixed Dietary Protein Intake Compliance (%): NR Energy balance status: Hypocaloric Study duration: 24 months</p>	<p>education and support for the first 6 months and then every 3 months for the next 18 months. Sample food packs of \$20 vouchers were provided to participants at baseline and 12 and 26 weeks. Each diet group was allocated to a protein target that was based on key protein foods as a compliance measure. Protein Assessment Method: Same as above Dietary Protein Intake Compliance: Same as above</p>	
<p>PMID: 25844619 Kerstetter 2015*#⁵ Location/Country: USA HDI: Very high Setting: NR Urban/ Rural: NR Study design: RCT (parallel) Funding source: Government, academic</p>	<p>Study of: Adults Total sample N: 208 Intervention: High Protein N: 106 % Female: 84% Mean Age (SD): 69.9 (6.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR</p>	<p>Intervention: High Protein Intended Protein Amount: 40 g of protein from the supplement; total daily protein goal NR Carbohydrate: Test food protein NR Fat: Test food protein NR Baseline Protein Amount</p>	<p>Intervention: High Protein How protein was administered: Participants received a dietary whey protein supplement (protein group; Provon 290; Glambia Nutritionals) that was closely matched for composition, color,</p>	<p>BMD of the Axial Skeleton - Bone mineral density (lumbar spine) Measure/Method of Assessment: DXA (Hologic 4500W or Lunar Prodigy DPX-IQ) BMD of the Appendicular - Bone mineral density (hip, total)</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>Risk of bias score: Low/High</p>	<p>Mean BMI (SD): 26.1 (3.4) kg/m² Income level: NR Education level: NR Mean Physical activity level score (SD): 6.7 (2.1) Health status/ Comorbidities: Healthy older adults Medication use: Excluded if using long-term chemotherapeutic drugs, aromatase inhibitors or tamoxifen, methotrexate, phenytoin, phenobarbital or inhaled corticosteroids (greater than 800 ug/day), actively being treated for leukemia or multiple myeloma, a change in thyroid medications, medications known to affect calcium metabolism or use of proton pump inhibitors twice daily Supplement use: Daily multivitamin mineral supplement (contained 400 IU of vitamin D); Ca carbonate supplement (300 mg tablets) Pregnant or lactating: NR</p> <p>Comparator: Low Protein N: 102 % Female: 87.3% Mean Age (SD): 70.5 (6.4) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR</p>	<p>Least Square Mean (SEM): 73.8 (1.9) g Carbohydrate Least Square Mean (SEM): 214.1 (5.2) g Fat Mean (SEM): 59.4 (2.1) g</p> <p>Actual Protein Amount at the end of the study Least Square Mean (SEM): 90.7 (3.3) g Carbohydrate Least Square Mean (SEM): 196.9 (6.6) g Fat Least Square Mean (SEM): 55.6 (2.0) g</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Animal; whey supplement</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Low Protein</p> <p>Intended Protein Amount: Test food protein NR Carbohydrate: Test food protein NR Fat: Test food protein NR</p> <p>Baseline Protein Amount Least Square Mean (SEM): 72.9 (1.8) g/day; 1.06 (0.03) g/kg/day (total daily) Carbohydrate Least Square Mean (SEM): 206.2 (5.8) g/day (total daily)</p>	<p>kilocalories, sodium, potassium, phosphorus, fiber, and calcium.</p> <p>Protein Assessment Method: Participants completed a 3-day food record prior to baseline, 6 months, and 18 months and were analyzed using the ESHA Food Processor software program (ESHA Research; version 10.1.0).</p> <p>Dietary Protein Intake Compliance: Urinary area was a compliance measure.</p> <p>Comparator: Low Protein</p> <p>How protein was administered: Participants received a maltodextrin supplement Maltrin M100; Grain Processing Corp) that was closely matched for composition, color, kilocalories, sodium, potassium, phosphorus, fiber, and calcium.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	<p>Measure/Method of Assessment: DXA (Hologic 4500W or Lunar Prodigy DPX-IQ)</p> <p>BMD of the Appendicular - Bone mineral density (femoral neck)</p> <p>Measure/Method of Assessment: DXA (Hologic 4500W or Lunar Prodigy DPX-IQ)</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Mean BMI (SD): 26.4 (4.0) kg/m² Income level: NR Education level: NR Mean physical activity level score (SD): 6.8 (1.9) Health status/ Comorbidities: Healthy older adults Medication use: Excluded if using long-term chemotherapeutic drugs, aromatase inhibitors or tamoxifen, methotrexate, phenytoin, phenobarbital or inhaled corticosteroids (greater than 800 ug/day), actively being treated for leukemia or multiple myeloma, a change in thyroid medications, medications known to affect calcium metabolism or use of proton pump inhibitors twice daily Supplement use: Daily multivitamin mineral supplement (contained 400 IU of vitamin D); Ca carbonate supplement (300 mg tablets) Pregnant or lactating: NR</p>	<p>Fat Least Square Mean (SEM): 61.3 (2.5) g/day (total daily) Actual Protein Amount at end of the study Least Square Mean (SEM): 72.7 (2.4) g/day; 1.05 (0.04) g/kg/day (total daily) Carbohydrate Least Square Mean (SEM): 229.0 (9.5) g/day (total daily) Fat Least Square Mean (SEM): 58.8 (2.4) g/day (total daily) Dietary Protein Intake Compliance (%): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 18 months</p>		
<p>PMID: 21194471 Li 2010^{*6} Location/Country: United States HDI: Very high Setting: Community dwelling Urban/ Rural: NR</p>	<p>Study of: Adults Total sample N: 85 Intervention: High Protein N: 44 % Female: 81.8% Mean Age (SD): 48.9 (11.8) y</p>	<p>Intervention: High Protein Intended Protein Amount: 2.2 g per kg of lean body mass; 30% of energy Carbohydrate: 40% of energy Fat: 30% of energy Baseline Protein Amount</p>	<p>Intervention: High Protein How protein was administered: Participants received isocaloric MR (Formula 1, Herbalife Intl., Los Angeles) with a protein</p>	<p>Total Body BMD - Bone mineral density (total body) Measure/Method of Assessment: DXA (Lunar Prodigy DEXA)</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>Study Design: RCT (parallel) Funding source: Industry Risk of bias score: High</p>	<p>Race/ Ethnicity: Asian: 9.1% Black: 20.5% Caucasian: 59.1% Hispanic: 9.1% Other: 2.2% Menopausal status: NR Obesity status: Obese Mean BMI (SD): 34.7 (6.8) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Inclusion: good health history; participants reported to be obese; Exclusion type 2 diabetes or glucose intolerance Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Comparator: Normal Protein N: 42 % Female: 63.4% Mean Age (SD): 49.7 (9.1) y Race/ Ethnicity: Asian: 2.4% Black: 19.5% Caucasian: 68.3% Hispanic: 4.9% Other: 4.9% Menopausal status: NR Obesity status: Obese Mean BMI (SD): 34.3 (10.3) kg/m² Income level: NR</p>	<p>Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Meal replacement protein: NR Diet: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Normal Protein</p> <p>Intended Protein Amount: 1.1 g per kg of lean body mass (15% total energy) Carbohydrate: 55% total energy Fat: 30% total energy</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p>	<p>supplement (Performance Protein Powder, Herbalife Intl., Los Angeles)</p> <p>Protein Assessment Method: Protein was assessed through qualitative food logs and reviewed with dietitians at follow-ups. Protein intake was measured at each follow-up visit; baseline, week 2, and months 1, 2, 3, 6, 9, 12.</p> <p>Dietary Protein Intake Compliance: No special efforts were made to assess compliance.</p> <p>Comparator: Normal Protein</p> <p>How protein was administered: Participants received the isocaloric MR (Formula 1, Herbalife Intl., Los Angeles) with matched carbohydrate placebo containing maltodextrin and flavoring</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	Education level: NR Physical activity level: NR Health status/ Comorbidities: Inclusion: good health history; participants reported to be obese; Exclusion type 2 diabetes or glucose intolerance Medication use: NR Supplement use: NR Pregnant or lactating: NR	Dietary Protein Intake Compliance (%): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 12 months		
PMID: 12055318 Skov 2002⁷ Location/Country: Denmark HDI: Very high Setting: NR Urban/ Rural: NR Study design: RCT (parallel) Funding source: Foundation Risk of bias score: Low	Study of: Adults Total sample N: 65 Intervention: High Protein N: 25 % Female: 76% Mean Age (SD): 39.4 (2.0) y Race/ Ethnicity: 100% White Menopausal status: NR Obesity status: Overweight or obese Mean BMI (SD): 30.8 (0.4) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/Co- morbidities: Participants were overweight or obese. Exclusion was current or previous disorders, primarily concerning renal function, metabolic diseases, and cardiovascular disease. Medication use: NR	Intervention: High Protein Intended Protein Amount: 25% of energy Carbohydrate: NR Fat: 30% of energy Baseline Protein Amount Mean (SEM): 89.1 (3.9) g/d Carbohydrate Mean (SEM): 256.2 (13.7) g/d Fat Mean (SEM): 96.6 (5.8) g/d Actual Protein Amount at the end of the study Mean (SEM): 102.5 (6.6) g/d Carbohydrate Mean (SEM): 316.5 (18.0) g/d Fat Mean (SEM): 76.9 (3.2) g/d Dietary Protein Intake Compliance (%): NR Protein type/source: Mixed Energy balance status: Eucaloric	Intervention: High Protein How protein was administered: Participants shopped for foods from a store designed for the study. Dietitians assured macronutrient distribution of selected items; energy contents of groceries were unknown to participants. Protein Assessment Method: Baseline protein assessment method was not reported. Actual Protein Amount during the intervention was derived from dietitians scanning the food participants chose from the intervention store. Dietary Protein Intake Compliance: Compliance to the diets was measured	Total Body BMC - Bone mineral content (total body) Measure/Method of Assessment: DXA (Hologic 1000/W, software version 5.61) BMD of the Axial Skeleton – Bone mineral density (regional lumbar) Measure/Method of Assessment: DXA (Hologic 1000/W, software version 5.61) Whole Body BMD - Bone mineral density (whole body) Measure/Method of Assessment: DXA (Hologic 1000/W, software version 5.61) Whole Body BMC - Bone mineral content (whole body) Measure/Method of Assessment: DXA (Hologic 1000/W, software version 5.61)

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Supplement use: NR Pregnant or lactating: NR</p> <p>Comparator: Low Protein N: 25 % Female: 76% Mean Age (SD): 39.8 (1.9) y Race/ Ethnicity: 100% White Menopausal status: NR Obesity status: Overweight or obese Mean BMI (SD): 30.0 (0.4) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/Co-morbidities: Participants were overweight or obese. Exclusion was current or previous disorders, primarily concerning renal function, metabolic diseases, and cardiovascular disease. Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Comparator: Low Protein</p> <p>Intended Protein Amount: 12% of energy Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SEM): 87.8 (5.0) g/day Carbohydrate Mean (SEM): 256.5 (11.6) g/d Fat Mean (SEM): 107.6 (7.9) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SEM): 70.5 (6.7) g/d Carbohydrate Mean (SEM): 302.4 (19.7) g/d Fat Mean (SEM): 72.9 (3.5) g/d</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 6 months</p>	<p>by 24-hour urinary nitrogen excretion.</p> <p>Comparator: Low Protein</p> <p>How protein was administered: Participants shopped for foods from a store designed for the study. Dietitians assured macronutrient distribution of selected items; energy contents of groceries were unknown to participants.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	
<p>PMID: 34581765 Stounbjerg 2021^{*8} Location/Country: Denmark HDI: Very high Setting: Community dwelling Urban/ Rural: Urban</p>	<p>Study of: Children and adolescents Total sample N: 200</p> <p>Intervention 1: Placebo-HP N: 50 % Female: 48%</p>	<p>Intervention 1: Placebo-HP</p> <p>Intended Protein Amount: 9.6 g/100g Carbohydrate: 5 g/100 g Fat: 0.2 g/100 g</p> <p>Baseline Protein Amount</p>	<p>Intervention 1: Placebo-HP</p> <p>How protein was administered: Participants took 300g/d for 6 days/week of a drained low-fat yogurt ("skyr") with a high protein</p>	<p>Bone Turnover Marker (Overall Turnover) - Osteocalcin</p> <p>Measure/Method of Assessment: Venous blood samples</p> <p>BMD of the Axial Skeleton - Bone mineral density (L1–L4 (lumbar spine vertebrae))</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>Study design: RCT (parallel) Funding source: Public-private partnership Risk of bias score: Low</p>	<p>Median Age (IQR): 7.8 (7.0–8.5) y Race/ Ethnicity: 100% White Pubertal status: 4% in puberty Obesity status: 14% obese Mean BMI-for-age z-score (SD): 0.02 (1.10) Income level: NR Parental education level: ≤Vocational or short academic: 16% Bachelor's degree: 36% ≥Master's degree: 48% Physical activity level: NR Health status/ Comorbidities: Exclusion criteria were an allergy or intolerance to milk or milk components, chronic disease. Medication use: Exclusion criteria: use of medication that might affect study outcomes. Supplement use: Exclusion criteria: habitual use of vitamin D-containing supplements >3 days/week for the prior 2 months and at all in the month immediately preceding the start of the intervention. Pregnant or lactating: NA</p> <p>Intervention 2: Vitamin D-HP N: 50</p>	<p>Mean (SD): 15.4 (2.4) % of energy Carbohydrate Mean (SD): 52.5 (4.7) % of energy Fat Mean (SD): 32.1 (4.7) % of energy</p> <p>Actual Protein Amount at the end of the study Mean (SD): 17.7 (3.3) % of energy Carbohydrate Mean (SD): 53.5 (5.6) % of energy Fat Mean (SD): 28.8 (4.9) % of energy</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Animal; low-fat yogurt</p> <p>Energy balance status: Eucaloric</p> <p>Intervention 2: Vitamin D-HP</p> <p>Intended Protein Amount: 9.6 g/100g Carbohydrate: 5 g/100 g Fat: 0.2 g/100 g</p> <p>Baseline Protein Amount Mean (SD): 15.7 (2.3) % of energy Carbohydrate Mean (SD): 52.0 (4.6) % of energy Fat Mean (SD): 32.4 (4.5) % of energy</p>	<p>content of 9-11 g protein/100 g plus a chewable placebo (from Oy Verman Ab) of identical appearance and taste were provided in identical, white tablet bottles containing 200 tablets.</p> <p>Protein Assessment Method: Protein amounts were derived from a dietary recording with a minimum of 3 recording days (4-day dietary record covering 3 consecutive weekdays and 1 weekend day) where parents weighed and recorded everything the child ate and drank (except water) in the web-based software Madlog (if weighing not possible, household measures were used). Protein intake was measured prior to baseline and at endpoint visits.</p> <p>Dietary Protein Intake Compliance: Parents recorded the child's daily intake of the specific yogurts during the intervention in recording sheets.</p> <p>Intervention 2: Vitamin D-HP</p>	<p>Measure/Method of Assessment: DXA (GE Lunar Prodigy scanner)</p> <p>BMC Axial Skeleton - Bone mineral content (L1-L4 (lumbar spine vertebrae))</p> <p>Measure/Method of Assessment: DXA (GE Lunah Prodigy scanner)</p> <p>Bone Geometry and Strength Indices - Bone area (L1–L4 (lumbar spine vertebrae))</p> <p>Measure/Method of Assessment: DXA (GE Lunah Prodigy scanner)</p> <p>BMD of the Axial Skeleton - Bone mineral density z-score (L1–L4 (lumbar spine vertebrae))</p> <p>Measure/Method of Assessment: DXA (GE Lunah Prodigy scanner) software computed zscores</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>% Female: 44% Median Age (IQR): 7.8 (7.3–8.2) y Race/ Ethnicity: 100% White Pubertal status: 4% in puberty Obesity status: 4% obese Mean BMI-for-age z-score (SD): – 0.15 (0.75) Income level: NR Parental education level: ≤Vocational or short academic: 16% Bachelor’s degree: 28% ≥Master’s degree: 56% Physical activity level: NR Health status/ Comorbidities: Exclusion criteria were an allergy or intolerance to milk or milk components, chronic disease. Medication use: Exclusion criteria: use of medication that might affect study outcomes. Supplement use: Exclusion criteria: habitual use of vitamin D–containing supplements >3 days/week for the prior 2 months and at all in the month immediately preceding the start of the intervention. Pregnant or lactating: NA</p> <p>Comparator 1: Placebo-NP</p>	<p>Actual Protein Amount at the end of the study Mean (SD): 19.0 (3.4) % of energy Carbohydrate Mean (SD): 49.6 (5.1) % of energy Fat Mean (SD): 31.4 (4.6) % of energy</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Animal; low-fat yogurt</p> <p>Energy balance status: Eucaloric</p> <p>Comparator 1: Placebo-NP</p> <p>Intended Protein Amount: 3.6 g/100g Carbohydrate: 8.6 g/100 g Fat: 2.3 g/100 g</p> <p>Baseline Protein Amount Mean (SD): 15.0 (2.2) % of energy Carbohydrate Mean (SD): 54.6 (4.8) % of energy Fat Mean (SD): 30.3 (4.5) % of energy</p> <p>Actual Protein Amount at the end of the study Mean (SD): 15.8 (2.7) % of energy Carbohydrate Mean (SD): 52.9 (4.9) % of energy Fat Mean (SD): 31.3 (4.3) % of energy</p>	<p>How protein was administered: Participants took 300g/d for 6 days/week of a drained low-fat yogurt (“skyr”) with a high protein content of 9-11 g protein/100 g plus a chewable 20 µg of vitamin D3 (Minisun; from Oy Verman Ab) of identical appearance and taste were provided in identical, white tablet bottles containing 200 tablets.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p> <p>Comparator 1: Placebo-NP</p> <p>How protein was administered: Participants took 300g/d for 6 days/week of a regular yogurt with protein content of 3.0 – 3.9 g protein/100 g plus a chewable placebo (from Oy Verman Ab) of identical appearance and taste were provided in identical, white tablet bottles containing 200 tablets.</p>	

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>N: 51 % Female: 53% Median Age (IQR): 7.6 (7.0–8.2) y Race/ Ethnicity: 100% White Pubertal status: 0% in puberty Obesity status: 16% obese Mean BMI-for-age z-score (SD): – 0.02 (1.12) Income level: NR Parental Education level: ≤Vocational or short academic: 20% Bachelor’s degree: 22% ≥Master’s degree: 59% Physical activity level: NR Health status/ Comorbidities: Exclusion criteria were an allergy or intolerance to milk or milk components, chronic disease. Medication use: Exclusion criteria: use of medication that might affect study outcomes. Supplement use: Exclusion criteria: habitual use of vitamin D–containing supplements >3 days/week for the prior 2 months and at all in the month immediately preceding the start of the intervention. Pregnant or lactating: NA</p>	<p>Protein type/source: Animal; yogurt</p> <p>Energy balance status: Eucaloric</p> <p>Comparator 2: Vitamin D-NP</p> <p>Intended Protein Amount: 3.6 g/100g Carbohydrate: 8.6 g/100 g Fat: 2.3 g/100 g</p> <p>Baseline Protein Amount Mean (SD): 15.7 (2.6) % of energy Carbohydrate Mean (SD): 54.5 (4.2) % of energy Fat Mean (SD): 29.7 (4.3) % of energy</p> <p>Actual Protein Amount at the end of the study Mean (SD): 16.0 (2.2) % of energy Carbohydrate Mean (SD): 51.7 (5.0) % of energy Fat Mean (SD): 32.3 (4.8) % of energy</p> <p>Protein type/source: Animal; yogurt</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 24 weeks</p>	<p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p> <p>Comparator 2: Vitamin D-NP</p> <p>How protein was administered: Participants took 300g/d for 6 days/week of a regular yogurt with protein content of 3.0 – 3.9 g protein/100 g plus a chewable placebo (from Oy Verman Ab) of identical appearance and taste were provided in identical, white tablet bottles containing 200 tablets.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Comparator 2: Vitamin D-NP N: 46 % Female: 61% Median Age (IQR): 7.6 (7.1–8.2) y Race/ Ethnicity: 100% White Pubertal status: 8% in puberty Obesity status: 16% obese Mean BMI-for-age z-score (SD): 0.34 (1.04) Income level: NR Parental education level: ≤Vocational or short academic: 10% Bachelor’s degree: 24% ≥Master’s degree: 65% Physical activity level: NR Health status/ Comorbidities: Exclusion criteria were an allergy or intolerance to milk or milk components, chronic disease. Medication use: Exclusion criteria: use of medication that might affect study outcomes. Supplement use: Exclusion criteria: habitual use of vitamin D–containing supplements >3 days/week for the prior 2 months and at all in the month immediately preceding the start of the intervention. Pregnant or lactating: NA</p>			

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>PMID: 21590739 Zhu 2011⁹ Location/Country: Australia HDI: Very high Setting: Community dwelling Urban/ Rural: Metropolitan Study design: RCT (parallel) Funding source: Government, academic Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 192</p> <p>Intervention: High Protein N: 101 % Female: 100% Mean Age (SD): 74.2 (2.8) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 26.1 (3.8) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 449 (391) MET-min/wk Health status/ Comorbidities: No previous osteoporotic fracture, currently or within last year taking medication for osteoporosis apart from calcium or vitamin D, or have taken more than 7 g in total in lifetime, metabolic bone disease apart from osteoporosis, total-hip bone density more than 2 SD below the mean for age, malabsorption disorders, celiac disease, clinical hepatic or renal insufficiency, clinical diagnosis of diabetes</p>	<p>Intervention: High Protein</p> <p>Intended Protein Amount: 30.1 g Carbohydrate: 13.2 g Fat: 2.3</p> <p>Baseline Protein Amount Mean (SD): 76 (18) g/d Carbohydrate Mean (SD): 185 (45) g/d Fat Mean (SD): 63 (18) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 95 (20) g/d Carbohydrate Mean (SD): 183 (52) g/d Fat Mean (SD): 62 (21) g/d</p> <p>Dietary Protein Intake Compliance (%): 81.1%</p> <p>Protein type/source: Animal; skim milk plus whey protein isolate</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Normal Protein</p> <p>Intended Protein Amount: 2.1 g Carbohydrate: 42.3 Fat: 2.0 g</p> <p>Baseline Protein Amount Mean (SD): 76 (16) g/d Carbohydrate Mean (SD): 190 (42) g/d</p>	<p>Intervention: High Protein</p> <p>How protein was administered: 250-mL skim milk–based high-protein supplement drink reconstituted with cold water from a powder that provided 30 g of protein (skim milk plus whey protein isolate; Alacen 894, Fonterra Brands, Ltd., Palmerston North, New Zealand), 600mg of calcium, and 3.2 kJ/mL of energy.</p> <p>Protein Assessment Method: Protein was reported at baseline, 1 year, and 2 years; assessed through 3-day weighed food records (2 weekdays, 1 weekend day)</p> <p>Dietary Protein Intake Compliance: Compliance was determined from empty test drink containers.</p> <p>Comparator: Normal Protein</p> <p>How protein was administered: 250-mL skim milk–based high-protein supplement drink reconstituted with cold</p>	<p>aBMD of the Appendicular Skeleton - Areal bone mineral density (hip, total)</p> <p>Measure/Method of Assessment: DXA (Hologic Discovery A fan-beam densitometer)]</p> <p>aBMD of the Appendicular Skeleton - Areal bone mineral density (femoral neck)</p> <p>Measure/Method of Assessment: DXA (Hologic Discovery A fan-beam densitometer)</p> <p>Total body vBMD - Volumetric bone mineral density (total body)</p> <p>Measure/Method of Assessment: QCT scans (Hologic Discovery A fan-beam densitometer)</p> <p>vBMD of the Appendicular Skeleton - Volumetric bone mineral density (femoral neck)</p> <p>Measure/Method of Assessment: QCT scans (Hologic Discovery A fan-beam densitometer)</p> <p>Bone Geometry and Strength Indices - Femoral neck cross-sectional area</p> <p>Measure/Method of Assessment: QCT scans (Hologic Discovery A fan-beam densitometer)</p> <p>Bone Geometry and Strength Indices - Femoral neck buckling ratio</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Medication use: Exclusion criteria: taking medication for osteoporosis apart from calcium or vitamin D, taking steroid tablets in the past 3 months or have taken more than 7 g in total in lifetime Supplement use: NR Pregnant or lactating: NA</p> <p>Comparator: Normal Protein N: 91 % Female: 100% Mean Age (SD): 74.3 (2.6) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 27.2 (4.0) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 398 (376) MET-min/wk Health status/ Comorbidities: No previous osteoporotic fracture, currently or within last year taking medication for osteoporosis apart from calcium or vitamin D, or have taken more than 7 g in total in lifetime, metabolic bone disease apart from osteoporosis, total-hip bone density</p>	<p>Fat Mean (SD): 63 (20) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 73 (17) g/d Carbohydrate Mean (SD): 204 (47) g/d Fat Mean (SD): 60 (17) g/d</p> <p>Dietary Protein Intake Compliance (%): 80.8%</p> <p>Protein type/source: Animal; skim milk plus whey protein isolate</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 2 y</p>	<p>water from a powder that provided 2.1 g of protein (skim milk plus whey protein isolate; Alacen 894, Fonterra Brands, Ltd., Palmerston North, New Zealand), 600mg of calcium, and 3.2 kJ/mL of energy</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	<p>Measure/Method of Assessment: QCT scans (Hologic Discovery A fan-beam densitometer)</p> <p>Bone Geometry and Strength Indices - Femoral neck polar CSMI (cross-sectional moment of inertia)</p> <p>Measure/Method of Assessment: QCT scans (Hologic Discovery A fan-beam densitometer)</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	more than 2 SD below the mean for age, malabsorption disorders, celiac disease, clinical hepatic or renal insufficiency, clinical diagnosis of diabetes Medication use: Exclusion criteria: taking medication for osteoporosis apart from calcium or vitamin D, taking steroid tablets in the past 3 months or have taken more than 7 g in total in lifetime Supplement use: NR Pregnant or lactating: NA			

Abbreviations: µg/L = micrograms per liter; BAP = Bone alkaline phosphatase; BMI = body mass index; BMC = bone mineral content; BMD = bone mineral density; CTX = carboxy terminal crosslinked telopeptide of type I collagen; DXA = Dual-energy x-ray absorptiometry; e.g. = exempli gratia; FFQ = food frequency questionnaire; g = grams; g/100g = grams per 100 grams; g/cm² = grams per centimeter squared; g/d = grams per day; HDI = human development index; HP = high protein; IQR = interquartile range; IU = international units; kg/m² = kilograms per meter squared; min/wk = minutes per week; mg = milligrams; mL = milliliter; MPB = milk based protein; MR = meal replacement; NA = not applicable; NP = normal protein; NR = not reported; P1NP = Procollagen type 1 N-terminal propeptide; PMID = PubMed Identification Number; RCT = randomized controlled trial; RoB = Risk of Bias; SD = standard deviation; SE = standard error; SEM = standard error of the mean; TRAP = (5b, tartrate resistant acid phosphatase, isoform 5); USA = United States of America; wk = week; y = year

Note: *Studies overlap KQs; **Child and Adolescent study; #: Kerstetter, 2015 reported on KQ1, KQ2, and KQ3 outcomes: KQ1 outcomes were assessed as both low (including BMD lumbar, hip and femoral outcomes) and high risk of bias (including all other reported outcomes)

Table C2. Evidence table for Bone Disease Non-Randomized Controlled Trials

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
PMID: 20219968 Beasley 2010 ¹⁰ Location/Country: USA HDI: Very high Setting: NR Urban/Rural: NR	Study of: Adults Total sample N: 560 Tertile 1: Protein intake 5.7-14.3% of energy (low) N: 186 % Female: 100% Mean Age (SD): 24.2 (6.6) y	Tertile 1: Protein intake 5.7-14.3% of energy (low) Baseline Protein Amount Mean (SD): Animal protein: 33.2 (18.1) g Vegetable protein: 18.6 (10.2) g	Protein Assessment Method: Protein intake was measured using an FFQ developed and evaluated in the Women's Health Initiative at the Fred Hutchinson Cancer Research Center. Consistent with current	BMD of the Axial Skeleton - Bone mineral density (lumbar spine) Measure/Method of Assessment: DXA (Hologic 2000 and Hologic 4500)

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
<p>Study design: Prospective cohort study Funding source: Government Risk of bias score: High</p>	<p>Race/ Ethnicity: White: 77% Black: 11% Other: 12% Menopausal status: Premenopausal Obesity status: NR Mean BMI (SD): 24.9 (5.2) kg/m² Income level: NR Education level: NR Mean physical activity level: 78.2 physical activity score Health status/ Comorbidities: Women with conditions known to affect bone mass were excluded. Medication use: Women taking medications known to affect bone mass were excluded. Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 2: Protein intake 14.4-17.1% of energy (medium) N: 187 % Female: 100% Mean Age (SD): 24.3 (6.9) y Race/ Ethnicity: White: 82% Black: 10% Other 8% Menopausal status: Premenopausal Obesity status: NR Mean BMI (SD): 24.5 (5.9) kg/m² Income level: NR Education level: NR</p>	<p>Carbohydrate Mean (SD): 55% of energy Fat Mean (SD): 33% of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 2: Protein intake 14.4-17.1% of energy (medium)</p> <p>Intended protein amount: NR Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): Animal protein: 43.3 (18.8) g Vegetable protein: 19.9 (9.2) g Carbohydrate Mean (SD): 52% of energy Fat Mean (SD): 33% of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3: Protein intake 17.2-27.6% of energy (high)</p> <p>Intended Protein Amount: NR Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): Animal protein: 58.7 (25.8) g Vegetable protein: 18.6 (8.2) g</p>	<p>dietary guidelines, protein was evaluated as a percentage of total energy. Protein intake was assessed at baseline and at annual follow-up visits.</p>	<p>BMD of the Appendicular Skeleton - Bone mineral density (hip, total)</p> <p>Measure/Method of Assessment: DXA (Hologic 2000 and Hologic 4500)</p> <p>Total Body BMD - Bone mineral density (total body)</p> <p>Measure/Method of Assessment: DXA (Hologic 2000 and Hologic 4500)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Mean physical activity level: 74.5 physical activity score Health status/ Comorbidities: Women with conditions known to affect bone mass were excluded. Medication use: Women taking medications known to affect bone mass were excluded. Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 3: Protein intake 17.2-27.6% of energy (high) N: 187 % Female: 100% Mean Age (SD): 25.4 (7.4) y Race/ Ethnicity: White: 76% Black: 15% Other 9% Menopausal status: Premenopausal Obesity status: NR Mean BMI (SD): 25.9 (5.3) kg/m² Income level: NR Education level: NR Mean physical activity level: 81.6 physical activity score Health status/ Comorbidities: Women with conditions known to affect bone mass were excluded. Medication use: Women taking medications known to affect bone mass were excluded. Supplement use: NR Pregnant or lactating: NR</p>	<p>Carbohydrate Mean (SD): 49% of energy Fat Mean (SD): 32% of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: Up to 3 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
<p>PMID: 24552750 Beasley 2014¹¹ Location/Country: USA HDI: Very high Setting: NR Urban/ Rural: NR Study design: Prospective cohort study Funding source: Government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 144,580</p> <p>Tertile 1: Protein intake <13.3% of energy N: NR % Female: 100% Mean Age (SD): 66 (7.2) y Race/ Ethnicity: White: 77.2% Black: 14.4% Hispanic: 3.9% American Indian: 0.5% Asian/Pacific Islander: 2.3% Unknown: 1.6% Menopausal status: Postmenopausal Obesity status: 37.5% Mean BMI (SD): NR Income level: NR Education level: NR Mean physical activity level: 9.9 METs/wk Health status/ Comorbidities: Fair/poor: 12.5% Good: 37.8% Excellent/very good: 49.7% Medication use: NR Supplement use: All participants supplemented with calcium and vitamin D Pregnant or lactating: NA</p> <p>Tertile 2: Protein intake 14.2-14.8% of energy N: NR % Female: 100% Mean Age (SD): 63.7 (6.9) y Race/ Ethnicity: White: 84.7% Black: 7.4%</p>	<p>Tertile 1: Protein intake <13.3% of energy</p> <p>Baseline Protein Amount: <13.3% of energy Carbohydrate: NR Fat: NR</p> <p>Actual Protein Amount at the end of the study: NR Carbohydrate: NR Fat: NR</p> <p>Tertile 2: Protein intake 14.2-14.8% of energy</p> <p>Baseline Protein Amount: 14.2-14.8% of energy Carbohydrate: NR Fat: NR</p> <p>Protein Amount at the end of the study: NR Carbohydrate: NR Fat: NR</p> <p>Tertile 3: Protein intake ≥15.6% of energy</p> <p>Baseline Protein Amount: ≥15.6% of energy Carbohydrate: NR Fat: NR</p> <p>Protein Amount at the end of the study: NR Carbohydrate: NR Fat: NR</p> <p>Protein type/source: Mixed</p>	<p>Protein Assessment Method: Self-administered FFQ that included 122 items for individual foods and food groups, 19 adjustment items, and summary questions. Protein intake was assessed at baseline.</p>	<p>Total Body BMD - Bone mineral density (total body)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR densitometer)</p> <p>BMD of the Appendicular Skeleton - Bone mineral density (hip, total)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR densitometer)</p> <p>BMD of the Axial Skeleton - Bone mineral density (spine)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR densitometer)</p> <p>Osteoporotic Fractures and Fracture Risk - Fragility fracture (osteoporotic and low-trauma fracture) Hip fracture Spine fracture Forearm fracture</p> <p>Measure/Method of Assessment: Self-report (CTs when available)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Hispanic: 3.4% American Indian: 0.3% Asian/ Pacific Islander: 2.7% Unknown: 1.4% Menopausal status: Postmenopausal Obesity status: 30.6% Mean BMI (SD): NR Income level: NR Education level: NR Mean physical activity level: 12.6 METs/w Health status/ Comorbidities: Fair/poor: 8.1% Good: 33.0% Excellent/very good: 58.9% Medication use: NR Supplement use: All participants supplemented with calcium and vitamin D Pregnant or lactating: NA</p> <p>Tertile 3: Protein intake ≥15.6% of energy N: NR % Female: 100% Mean Age (SD): 59.6 (6.4) y Race/ Ethnicity: White: 85.1% Black: 6.0% Hispanic: 4.1% American Indian: 0.4% Asian/ Pacific Islander: 3.1% Unknown: 1.3% Menopausal status: Postmenopausal Obesity status: 21.1% Mean BMI (SD): NR Income level: NR Education level: NR</p>	<p>Energy balance status: Eucaloric</p> <p>Study duration: 6 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	Mean physical activity level: 15.0 METs/wk Health status/ Comorbidities: Fair/poor: 6.5% Good: 27.3% Excellent/very good: 66.2% Medication use: NR Supplement use: All participants supplemented with calcium and vitamin D Pregnant or lactating: NA			
PMID: 26988112 Cauley 2016 ¹² Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study design: Prospective cohort study Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 5,876 Arm 1: No hip fracture N: 5,698 % Female: 0% Mean Age (SD): 73.48 (5.81) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: 76.11% ≥High school Mean physical activity level: 147.58 PASE score Health status/ Comorbidities: Participants who could not walk without the assistance of another or had bilateral hip replacements excluded. Medication use: Participants taking osteoporosis medications excluded. Supplement use: NR Pregnant or lactating: NA Arm 2: Hip fracture	Arm 1: No hip fracture Baseline Protein Amount Mean (SD): 16.13 (2.91) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Arm 2: Hip fracture Baseline Protein Amount Mean (SD): 15.3 (2.55) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein type/source: Mixed	Protein Assessment Method: Block 98 semiquantitative FFQ was administered. Diet quality was calculated using the validated Quality Index Revised. Protein intake was assessed at baseline.	Osteoporotic Fractures and Fracture Risk - Hip fracture Measure/Method of Assessment: Self-report & physician adjudicated of medical records

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>N: 178 % Female: 0% Mean Age (SD): 77.81 (6.08) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: 72.47% ≥High school Mean physical activity level: 131.89 PASE score Health status/ Comorbidities: Participants who could not walk without the assistance of another or had bilateral hip replacements excluded. Medication use: Participants taking osteoporosis medications excluded. Supplement use: NR Pregnant or lactating: NA</p>	<p>Energy balance status: Eucaloric</p> <p>Study duration: 8.6 y</p>		
<p>PMID: 21437561 Chan 2011¹³ Location/Country: China HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study design: Prospective cohort study Funding source: Government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 2,217</p> <p>Arm 1: Men N: 1,225 % Female: 0% Mean Age (SD): 71.6 (4.6) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 23.5 (3.1) kg/m² Income level: NR Education level: 41.1% secondary school or above Mean physical activity level: 101.7 PASE score</p>	<p>Arm 1: Men</p> <p>Baseline Protein Amount Mean (SD): 88.8 (35.3) g/d Carbohydrate Mean (SD): NR Fat Mean (Range): 23.4 (16.4-28.1) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (Range): NR</p> <p>Arm 2: Women</p> <p>Baseline Protein Amount Mean (SD): 65.7 (27.5) g/d</p>	<p>Protein Assessment Method: Dietary intake was assessed at baseline using an FFQ. Mean nutrient quantification per day was calculated using food tables derive from McCance and Widdowson and the Chinese Medical Sciences Institute.</p>	<p>BMD of the Appendicular Skeleton - Bone mineral density (hip, total)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR-4500 W densitometers)</p> <p>BMD of the Appendicular Skeleton - Bone mineral density (femoral neck)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR-4500 W densitometers)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Health status/ Comorbidities: Participants who had any detectable disease or medication known to affect bone mass were excluded. Medication use: Participants who were taking medication known to affect bone mass were excluded. Supplement use: 9.6% used calcium supplements Pregnant or lactating: NA</p> <p>Arm 2: Women N: 992 % Female: 100% Mean Age (SD): 72.0 (5.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.0 (3.5) kg/m² Income level: NR Education level: 17.4% secondary school or above Mean physical activity level: 87.6 PASE score Health status/ Comorbidities: Participants who had any detectable disease or medication known to affect bone mass were excluded. Medication use: Participants who were taking medication known to affect bone mass were excluded. Supplement use: 15.0% used calcium supplements Pregnant or lactating: NR</p>	<p>Carbohydrate Mean (SD): NR Fat Mean (Range): 16.4 (9.4-21.6) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (Range): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 4 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
<p>PMID: 18665794 Dargent-Molina 2008¹⁴ Location/Country: France HDI: Very high Setting: NR Urban/ Rural: NR Study design: Prospective cohort study Funding source: Government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 36,217</p> <p>Arm 1: No fractures N: 33,809 % Female: 100% Mean Age (SD): 56.1 (5.5) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 23.2 (3.3) kg/m² Income level: NR Education level: NR Mean physical activity level: 52.7 METS/d Health status/ Comorbidities: NR Medication use: NR Supplement use: 20.8% used calcium supplements Pregnant or lactating: NA</p> <p>Arm 2: Fractures N: 2,408 % Female: 100% Mean Age (SD): 57.1 (5.6) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 23.3 (3.4) kg/m² Income level: NR Education level: NR Mean physical activity level: 53.7 METS/d Health status/ Comorbidities: NR Medication use: NR</p>	<p>Arm 1: No fractures</p> <p>Baseline Protein Amount Mean (SD): 45.7 (7.3) g/1000 kcal/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 2: Fractures</p> <p>Baseline Protein Amount Mean (SD): 46.0 (7.6) g/1000 kcal/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 15 y</p>	<p>Protein Assessment Method: The dietary questionnaire was composed of two parts, the first including questions on the consumption (quantity and frequency) of food groups and the second qualitative questions allowing detailing the food groups into food items. The questionnaire assessed dietary consumption of 208 items. It was sent with a booklet of photos to facilitate the estimation of portion sizes. Protein intake was assessed at baseline.</p>	<p>Osteoporotic Fractures and Fracture Risk - Fragility fracture (osteoporotic and low-trauma fracture) Measure/method of assessment: Self-report</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	Supplement use: 12.2% used calcium supplements Pregnant or lactating: NA			
PMID: 15941897 Devine 2005¹⁵ Location/Country: Australia HDI: Very high Setting: NR Urban/ Rural: NR Study design: Prospective cohort study Funding source: Nonprofit, government Risk of bias score: High	Study of: Adults Total sample N: 1,077 Arm 1: Whole cohort N: 1,077 % Female: 100% Mean Age (SD): 75 (3) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 27.1 (4.5) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Participants excluded if they had significant current illness. Medication use: Participants excluded if receiving pharmaceutical agents that act on bone, including calcium supplements. Supplement use: Participants excluded if receiving pharmaceutical agents that act on bone, including calcium supplements. Pregnant or lactating: NA	Arm 1: Whole cohort Baseline Protein Amount Mean (SD): 80.5 (27.8) g Carbohydrate Mean (SD): 192 (59) g Fat Mean (SD): 64.5 (24.5) g Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 1 y	Protein Assessment Method: Each subject completed a self-administered, semiquantitative FFQ developed by the Anti-Cancer Council of Victoria (ACCV) from which information on the daily dietary intakes of energy, carbohydrate, protein, fat, and calcium was derived. Protein intake was assessed at baseline.	BMD of the Appendicular Skeleton - Bone mineral density (hip, total) Measure/Method of Assessment: DXA (Acclaim QDR 4500A fan-beam densitometer) BMD of the Appendicular Skeleton - Bone mineral density (trochanter) Measure/Method of Assessment: DXA (Acclaim QDR 4500A fan-beam densitometer) BMD of the Appendicular Skeleton - Bone mineral density (intertrochanter) Measure/Method of Assessment: DXA (Acclaim QDR 4500A fan-beam densitometer) BMD of the Appendicular Skeleton - Bone mineral density (femoral neck) Measure/Method of Assessment: DXA (Acclaim QDR 4500A fan-beam densitometer)
PMID: 11127216 Hannan 2000¹⁶	Study of: Adults Total sample N: 855	Arm 1: Attended both exams	Protein Assessment Method: Dietary intake was assessed using the 126-item	BMD of the Axial Skeleton - Bone mineral density, mean percent bone loss (spine)

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
Location/Country: USA HDI: Very high Setting: NR Urban/ Rural: NR Study design: Prospective cohort study Funding source: Government Risk of bias score: High	<p>Arm 1: Attended both exams N: 615 % Female: 64% Mean Age (SD): 74.5 (4.4) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: 7% estrogen use Supplement use: NR Pregnant or lactating: NR</p> <p>Arm 2: Attended only baseline exam N: 240 % Female: 55% Mean Age (SD): 77.2 (5.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: 3% estrogen use Supplement use: NR Pregnant or lactating: NR</p>	<p>Baseline Protein Amount Mean (SD): 68.5 (23.6) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 2: Attended only baseline exam</p> <p>Baseline Protein Amount Mean (SD): 66.8 (24.4) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 4 y</p>	Willett FFQ. Data were converted to food and nutrient intake data. Protein intake was assessed at baseline and two years later.	<p>Measure/Method of Assessment: DXA (DPX-L densitometer)</p> <p>BMD of the Appendicular Skeleton - Bone mineral density, mean percent bone loss (hip)</p> <p>Measure/Method of Assessment: DXA (DPX-L densitometer)</p> <p>BMD of the Appendicular Skeleton - Bone mineral density, mean percent bone loss (radius)</p> <p>Measure/Method of Assessment: DXA (DPX-L densitometer)</p>
PMID: 25192416 Hu 2014 ¹⁷ Location/Country: USA HDI: Very high	<p>Study of: Adults Total sample N: 1,658</p> <p>Quartile 1: Protein intake 6.1–13.6% of energy</p>	<p>Quartile 1: Protein intake 6.1–13.6% of energy</p> <p>Baseline Protein Amount Mean (SD): 49.6 (24.5) g</p>	<p>Protein Assessment Method: A 120-item FFQ was used to assess usual food intake of specific foods and beverages over the past</p>	<p>vBMD of the Axial Skeleton - Volumetric bone mineral density (lumbar spine)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
<p>Setting: Community dwelling Urban/ Rural: NR Study design: Prospective cohort study Funding source: Nonprofit, government, academic Risk of bias score: High</p>	<p>N: 414 % Female: 45.8% Mean Age (SD): 62.2 (9.9) y Race/ Ethnicity: White: 46.1% Chinese: 6.1% Black: 21.7% Hispanic: 26.1% Menopausal status: NR Obesity status: NR Mean BMI (SD): 28.2 (5.2) kg/m² Income level: NR Education level: ≥College-level education: 64.4% Mean physical activity level: 5,249 MET-min/week Health status/ Comorbidities: Participants free of CVD included. Medication use: NR Supplement use: 63.4% take multivitamin Pregnant or lactating: NR</p> <p>Quartile 2: Protein intake 13.7–15.7% of energy N: 415 % Female: 44.5% Mean Age (SD): 63.4 (10) y Race/ Ethnicity: White: 45.2% Chinese: 8.6% Black: 21.3% Hispanic: 24.9% Menopausal status: NR Obesity status: NR Mean BMI (SD): 28.2 (5.0) kg/m² Income level: NR Education level:</p>	<p>Carbohydrate Mean (SD): 55.8 (10.4) % of energy Fat Mean (SD): 30.8 (7.9) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 2: Protein intake 13.7–15.7% of energy</p> <p>Baseline Protein Amount Mean (SD): 59.2 (28.7) (g) Carbohydrate Mean (SD): 53.5 (7.8) % of energy Fat Mean (SD): 31.5 (6.6) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 3: Protein intake 15.8–17.9% of energy</p> <p>Baseline Protein Amount Mean (SD): 64.5 (30.4) g Carbohydrate Mean (SD): 52.1 (7.5) % of energy Fat Mean (SD): 31.4 (6.6) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p>	<p>year. For each food item, the consumption frequency (times/d, week or month) and serving size (small, medium or large) were recorded. Protein intake was assessed at baseline.</p>	<p>Measure/Method of Assessment: CT scan ([Imatron C-150 or a multi-detector CT system that utilized helical scanning with reconstruction in 5 mm thick cuts and 350 mm field of view])</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>≥College-level education: 65.3%</p> <p>Mean physical activity level: 5,399 MET-min/week</p> <p>Health status/ Comorbidities: Participants free of CVD included.</p> <p>Medication use: NR</p> <p>Supplement use: 61.4% take multivitamin</p> <p>Pregnant or lactating: NR</p> <p>Quartile 3: Protein intake 15.8–17.9% of energy N: 413 % Female: 49.6% Mean Age (SD): 61.5 (10) y</p> <p>Race/ Ethnicity: White: 39.2% Chinese: 15.3% Black: 17.3% Hispanic: 28.2%</p> <p>Menopausal status: NR</p> <p>Obesity status: NR</p> <p>Mean BMI (SD): 27.9 (5.0) kg/m²</p> <p>Income level: NR</p> <p>Education level: ≥College-level education: 62.8%</p> <p>Mean physical activity level: 5,101 MET-min/week</p> <p>Health status/ Comorbidities: Participants free of CVD included.</p> <p>Medication use: NR</p> <p>Supplement use: 59.9% take multivitamin</p> <p>Pregnant or lactating: NR</p> <p>Quartile 4: Protein intake 18.0–33.5% of energy</p>	<p>Quartile 4: Protein intake 18.0–33.5% of energy</p> <p>Baseline Protein Amount Mean (SD): 71.5 (35.1) g</p> <p>Carbohydrate Mean (SD): 49.6 (8.2) % of energy</p> <p>Fat Mean (SD): 30.7 (6.9) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR</p> <p>Carbohydrate Mean (SD): NR</p> <p>Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 5 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>N: 416 % Female: 53.4% Mean Age (SD): 62.1 (9.3) y Race/ Ethnicity: White: 36.5% Chinese: 26.0% Black: 12.5% Hispanic: 25.0% Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.8 (5.2) kg/m² Income level: NR Education level: ≥College-level education: 66.6% Mean physical activity level: 4,989 MET-min/week Health status/ Comorbidities: Participants free of CVD included. Medication use: NR Supplement use: 65.9% take multivitamin Pregnant or lactating: NR</p>			
<p>PMID: 17381900 Key 2007¹⁸ Location/Country: Australia HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study design: Prospective cohort study Funding source: Government, nonprofit Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 34,696</p> <p>Arm 1: Women N: 26,749 % Female: 100% Mean Age (SD): 45.8 (13.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 23.6 (3.9) kg/m² Income level: NR Education level: NR</p>	<p>Arm 1: Women</p> <p>Baseline Protein Amount Mean (SD): 73.1 (21.6) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 2: Men</p> <p>Baseline Protein Amount Mean (SD): 77.8 (22.6) g/d</p>	<p>Protein Assessment Method: An FFQ was used to estimate participants average frequency intake of each of 130 foods and drinks. Nutrient intakes were estimated by multiplying the nutrient content of a specific portion size of each food by the frequency of consumption, using food composition tables. Protein intake was assessed over the previous 12 months.</p>	<p>Osteoporotic Fractures and Fracture Risk - Fragility fracture (osteoporotic and low-trauma fracture) Fracture Measure/method of assessment: Self-report</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Physical activity level: 27.6% (≥ 3 hours vigorous exercise per week)</p> <p>Health status/ Comorbidities: NR</p> <p>Medication use: 13.5% hormone replacement therapy</p> <p>Supplement use: 61.2% take dietary supplements</p> <p>Pregnant or lactating: NR</p> <p>Arm 2: Men N: 7,947 % Female: 0% Mean Age (SD): 49.5 (13.5) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 24.2 (3.3) kg/m² Income level: NR Education level: NR Physical activity level: 34.3% (≥ 3 hours vigorous exercise per week)</p> <p>Health status/ Comorbidities: NR</p> <p>Medication use: NR</p> <p>Supplement use: 44.2% take dietary supplements</p> <p>Pregnant or lactating: NA</p>	<p>Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Plant</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 6 y</p>		
<p>PMID: 26412291 Langsetmo 2015¹⁹ Location/Country: Canada HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study design: Prospective cohort study</p>	<p>Study of: Adults Total sample N: 6,510</p> <p>Arm 1: Men N: 1,919 % Female: 0% Mean Age (SD): NR Race/ Ethnicity: NR Menopausal status: NA</p>	<p>Arm 1: Men</p> <p>Baseline Protein Amount Median (IQR): 13.6 (12.0-15.1) % of energy Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p>	<p>Protein Assessment Method: A FFQ was derived from items on the short form Block questionnaire with modifications according to the Canadian diet. A standard portion size was specified with frequency ranging from never/ less than</p>	<p>BMD of the Appendicular Skeleton - Bone mineral density (hip, total)</p> <p>Measure/Method of Assessment: DXA (Hologic densitometers)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
<p>Funding source: Government, industry, pharmaceutical Risk of bias score: High</p>	<p>Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Arm 2: Women N: 4,591 % Female: 100% Mean Age (SD): NR Race/ Ethnicity: NR Menopausal status: Premenopausal and postmenopausal Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Arm 2: Women</p> <p>Baseline Protein Amount Median (IQR): 14.3 (12.8-15.9) % of energy Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Protein type/source: Mixed</p> <p>Energy Balance status: Eucaloric</p> <p>Study duration: 5 y</p>	<p>once a month to 6 or more times per day. Total energy intake (TEI) and protein intake were calculated by using the frequency and specified portion size from the questionnaire together with content information from the Canadian Nutrient File. Protein intake was assessed during Year 2 follow-up.</p>	<p>BMD of the Axial Skeleton - Bone mineral density (L1-L4 (lumbar spine))</p> <p>Measure/Method of Assessment: DXA (Hologic densitometers)</p> <p>Osteoporotic Fractures and Fracture Risk – Fragility fracture (osteoporotic and low-trauma fracture)</p> <p>Measure/Method of Assessment: Self-report</p>
<p>PMID: 27943394 Langsetmo 2017²⁰ Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study design: Prospective cohort study Funding source: Government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 5,875</p> <p>Quartile 1: Protein intake 6.0-14.1% of energy N: 1,469 % Female: 0% Mean Age (SD): 73.6 (5.9) y Race/ Ethnicity: 87.3% non-Hispanic white Menopausal status: NA Obesity status: NR</p>	<p>Quartile 1: Protein intake 6.0-14.1% of energy</p> <p>Baseline Protein Amount Range: 6.0-14.1% of energy Carbohydrate Range: NR Fat Range: NR</p> <p>Protein Amount at the end of the study Range: NR Carbohydrate Range: NR Fat Range: NR</p>	<p>Protein Assessment Method: Participants completed a modified version of the original Block FFQ. The FFQ asked 69 individual food item questions, including an additional 13 questions about food preparation and low-fat foods which were used to refine nutrient calculations. Total energy intake, total protein intake, and protein intake by</p>	<p>Osteoporotic Fractures and Fracture Risk - Incident fracture</p> <p>Measure/Method of Assessment: Radiographic reports.</p> <p>Osteoporotic Fractures and Fracture Risk – Fragility fracture (osteoporotic and low-trauma fracture)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Mean BMI (SD): 27.3 (3.8) kg/m² Income level: NR Education level: Post-secondary degree: 45.3% Mean physical activity level: 147.9 PASE score Health status/ Comorbidities: Osteoporosis: 3.3% Medication use: Corticosteroid medication: 2.3% Supplement use: Calcium/Vitamin D supplements: 32.5% Pregnant or lactating: NA</p> <p>Quartile 2: Protein intake 14.2-15.8% of energy N: 1,469 % Female: 0% Mean Age (SD): 74.0 (5.8) y Race/ Ethnicity: 90.5% non-Hispanic white Menopausal status: NA Obesity status: NR Mean BMI (SD): 27.3 (3.6) kg/m² Income level: NR Education level: Post-secondary degree: 52.0% Mean physical activity level: 145.0 PASE score Health status/ Comorbidities: Osteoporosis: 3.8% Medication use: Corticosteroid medication: 2.0%</p>	<p>Quartile 2: Protein intake 14.2-15.8% of energy</p> <p>Baseline Protein Amount Range: 14.2-15.8% of energy Carbohydrate Range: NR Fat Range: NR</p> <p>Protein Amount at the end of the study Range: NR Carbohydrate Range: NR Fat Range: NR</p> <p>Quartile 3: Protein intake 15.9-17.7% of energy</p> <p>Baseline Protein Amount Range: 15.9-17.7% of energy Carbohydrate Range: NR Fat Range: NR</p> <p>Protein Amount at the end of the study Range: NR Carbohydrate Range: NR Fat Range: NR</p> <p>Quartile 4: Protein intake 17.8-29.3% of energy</p> <p>Baseline Protein Amount Range: 17.8-29.3% of energy Carbohydrate Range: NR Fat Range: NR</p> <p>Protein Amount at the end of the study Range: NR Carbohydrate Range: NR Fat Range: NR</p>	<p>source were derived from the responses to the questionnaire by Block Dietary Data Systems. Protein intake was assessed at baseline.</p>	<p>Hip fracture Spine fracture</p> <p>Measure/Method of Assessment: Radiographic reports</p> <p>BMD of the Appendicular Skeleton - Bone mineral density (hip, total)</p> <p>Measure/Method of Assessment: QDR 4500 fanbeam densitometers</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Supplement use: Calcium/Vitamin D supplements: 36% Pregnant or lactating: NA</p> <p>Quartile 3: Protein intake 15.9-17.7% of energy N: 1,469 % Female: 0% Mean Age (SD): 73.6 (5.9) y Race/ Ethnicity: 91.0% non-Hispanic white Menopausal status: NA Obesity status: NR Mean BMI (SD): 27.4 (3.9) kg/m² Income level: NR Education level: Post-secondary degree: 57.3% Mean physical activity level: 149.0 PASE score Health status/ Comorbidities: Osteoporosis: 2.8% Medication use: Corticosteroid medication: 2.5% Supplement use: Calcium/Vitamin D supplements: 37.8% Pregnant or lactating: NA</p> <p>Quartile 4: Protein intake 17.8-29.3% of energy N: 1,468 % Female: 0% Mean Age (SD): 73.4 (5.9) y Race/ Ethnicity: 90.2% non-Hispanic white Menopausal status: NA Obesity status: NR</p>	<p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 15 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	Mean BMI (SD): 27.5 (4.1) kg/m ² Income level: NR Education level: Post-secondary degree: 58.6% Mean physical activity level: 144.1 PASE score Health status/ Comorbidities: Osteoporosis: 4.2% Medication use: Corticosteroid medication: 1.6% Supplement use: Calcium/Vitamin D supplements: 36.7% Pregnant or lactating: NA			
PMID: 36986162 Liu 2023²¹ Location/Country: China HDI: High Setting: Community dwelling Urban/ Rural: Urban Study design: Prospective cohort study Funding source: Nonprofit, government, academic Risk of bias score: High	Study of: Adults Total sample N: 1,987 Quartile 1: Protein intake <0.96 g of protein/kg/d N: 497 % Female: 65.8% Mean Age (SD): 60.3 (5.0) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.1 (3.1) kg/m ² Income level: 58.3% (income <3,000 Yuan (month-person)) Education level: NR Mean physical activity level: 24.1 METS/wk Health status/ Comorbidities: Stroke: 2.0% Hypertension: 29.4% Hyperlipidemia: 38.7%	Quartile 1: Protein intake <0.96 g of protein/kg/d Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): 14.9 (4.7) % of energy Carbohydrate Mean (SD): 57.6 (22.1) % of energy Fat Mean (SD): 21.2 (14.4) % of energy Quartile 2: Protein intake 0.96~ g of protein/kg/d Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR	Protein Assessment Method: Dietary intake was assessed using a validated 79-item FFQ to estimate habitual food intakes. For each food item, its frequency (never or per year, month, week, or day) of consumption and the regular serving size were estimated. The dietary intake of total energy, protein, amino acids, and other nutrients was calculated according to the Chinese Food Composition Table 2009. Protein intake was assessed at the first follow-up.	Total Body BMD - Bone mineral density (total body) Measure/Method of Assessment: DXA (Hologic QDR1000, version 6.10) BMD of the Axial Skeleton - Bone mineral density (L1-L4 (lumbar spine)) Measure/Method of Assessment: DXA (Hologic QDR1000, version 6.10) BMD of the Appendicular Skeleton - Bone mineral density (hip, total) Measure/Method of Assessment: DXA (Hologic QDR1000, version 6.10)

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Medication use: NR Supplement use: Calcium supplements: 30.2% Multivitamin supplements: 17.1% Pregnant or lactating: NR</p> <p>Quartile 2: Protein intake ~0.96 g of protein/kg/d N: 497 % Female: 69.8% Mean Age (SD): 60.4 (4.7) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.1 (2.4) kg/m² Income level: 54.1% (income <3,000 Yuan (month-person) Education level: NR Mean physical activity level: 25.3 METS/wk Health status/ Comorbidities: Stroke: 1.6% Hypertension: 24.6% Hyperlipidemia: 41.7% Medication use: NR Supplement use: Calcium supplements: 27.8% Multivitamin supplements: 17.5% Pregnant or lactating: NR</p> <p>Quartile 3: Protein intake 1.10~ g of protein/kg/d N: 497 % Female: 72.2% Mean Age (SD): 60.3 (4.8) y</p>	<p>Protein Amount at the end of the study Mean (SD): 16.9 (4.9) % of energy Carbohydrate Mean (SD): 59.1 (25.4) % of energy Fat Mean (SD): 32.1 (16.3) % of energy</p> <p>Quartile 3: Protein intake ~1.10 g of protein/kg/d</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): 17.8 (5.5) % of energy Carbohydrate Mean (SD): 58.3 (24.9) % of energy Fat Mean (SD): 31.6 (14.8) % of energy</p> <p>Quartile 4: Protein intake ≥1.26 g of protein/kg/d</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): 20.3 (6.6) % of energy Carbohydrate Mean (SD): 61.2 (25.8) % of energy</p>		<p>BMD of the Appendicular Skeleton - Bone mineral density (femoral neck)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR1000, version 6.10)</p> <p>BMD of the Appendicular Skeleton - Bone mineral density (trochanter)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR1000, version 6.10)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 22.8 (2.3) kg/m² Income level: 56.1% (income <3,000 Yuan (month-person) Education level: NR Mean physical activity level: 25.2 METS/wk Health status/ Comorbidities: Stroke: 1.8% Hypertension: 25.5% Hyperlipidemia: 38.0% Medication use: NR Supplement use: Calcium supplements: 30.8% Multivitamin supplements: 22.3% Pregnant or lactating: NR</p> <p>Quartile 4: Protein intake ≥1.26 g of protein/kg/d N: 496 % Female: 78.8% Mean Age (SD): 60.1 (5.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 21.1 (2.4) kg/m² Income level: 62.3% (income <3,000 Yuan (month-person) Education level: NR Mean physical activity level: 25.7 METS/wk Health status/ Comorbidities:</p>	<p>Fat Mean (SD): 32.5 (15.6) % of energy</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 6 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	Stroke: 1.8% Hypertension: 25.5% Hyperlipidemia: 39.3% Medication use: NR Supplement use: Calcium supplements: 30.6% Multivitamin supplements: 22.0% Pregnant or lactating: NR			
PMID: 28179224 Mangano 2017^{*22} Location/Country: USA HDI: Very high Setting: NR Urban/ Rural: NR Study design: Prospective cohort study Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 2,986 Arm 1: Protein food cluster (Fast food, full-fat dairy) N: 458 % Female: 44% Mean Age (SD): 39.3 (8.5) y Race/ Ethnicity: NR Menopausal status: 6% nonestrogenic Obesity status: NR Mean BMI (SD): 26.5 (5.0) kg/m ² Income level: NR Education level: NR Mean physical activity level: 37.2 PAI Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 19%, Vitamin D supplements: 40% Pregnant or lactating: NR Arm 2: Protein food cluster 2 (Fish) N: 605 % Female: 58% Mean Age (SD): 42.2 (9.0) y	Arm 1: Protein food cluster (Fast food, full-fat dairy) Baseline Protein Amount Mean (SD): 88 (31) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Arm 2: Protein food cluster 2 (Fish) Baseline Protein Amount Mean (SD): 90 (31) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Arm 3: Protein food cluster 3 (Red meat) Baseline Protein Amount	Protein Assessment Method: Typical dietary intakes of foods and nutrients were assessed with the use of the Harvard 126-item semiquantitative and validated general population 88 FFQ. Protein intake was assessed during the years 2002-2005.	BMD of the Appendicular Skeleton - Bone mineral density (femoral neck) Measure/Method of Assessment: GE Lunar Prodigy fan-beam densitometer BMD of the Appendicular Skeleton - Bone mineral density (hip, total) Measure/Method of Assessment: GE Lunar Prodigy fan-beam densitometer BMD of the Appendicular Skeleton - Bone mineral density (trochanter) Measure/Method of Assessment: GE Lunar Prodigy fan-beam densitometer BMD of the Axial Skeleton - Bone mineral density (lumbar spine)

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Race/ Ethnicity: NR Menopausal status: 14% nonestrogenic Obesity status: NR Mean BMI (SD): 26.8 (5.3) kg/m² Income level: NR Education level: NR Mean physical activity level: 37.4 PAI Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 43%, Vitamin D supplements: 53% Pregnant or lactating: NR</p> <p>Arm 3: Protein food cluster 3 (Red meat) N: 640 % Female: 48% Mean Age (SD): 41.5 (8.3) y Race/ Ethnicity: NR Menopausal status: 13% nonestrogenic Obesity status: NR Mean BMI (SD): 27.4 (5.6) kg/m² Income level: NR Education level: NR Mean physical activity level: 37.5 PAI Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 30% Vitamin D supplements: 39% Pregnant or lactating: NR</p>	<p>Mean (SD): 97 (29) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 4: Protein food cluster 4 (Chicken)</p> <p>Baseline Protein Amount Mean (SD): 95 (35) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 5: Protein food cluster 5 (Low-fat milk)</p> <p>Baseline Protein Amount Mean (SD): 98 (31) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 6: Protein food cluster 6 (Legumes)</p> <p>Baseline Protein Amount</p>		<p>Measure/Method of Assessment: GE Lunar Prodigy fan-beam densitometer</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Arm 4: Protein food cluster 4 (Chicken) N: 735 % Female: 58% Mean Age (SD): 39.3 (8.3) y Race/ Ethnicity: NR Menopausal status: 7% nonestrogenic Obesity status: NR Mean BMI (SD): 26.7 (5.3) kg/m² Income level: NR Education level: NR Mean physical activity level: 37.0 PAI Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 36%, Vitamin D supplements: 46% Pregnant or lactating: NR</p> <p>Arm 5: Protein food cluster 5 (Low-fat milk) N: 434 % Female: 58% Mean Age (SD): 40.9 (8.6) y Race/ Ethnicity: NR Menopausal status: 11% nonestrogenic Obesity status: NR Mean BMI (SD): 26.8 (5.0) kg/m² Income level: NR Education level: NR Mean physical activity level: 37.8 PAI Health status/ Comorbidities: NR</p>	<p>Mean (SD): 83 (34) g/d Carbohydrate: NR Fat: NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 9 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Medication use: NR Supplement use: Calcium supplements: 40%, Vitamin D supplements: 50% Pregnant or lactating: NR</p> <p>Arm 6: Protein food cluster 6 (Legumes) N: 114 % Female: 79% Mean Age (SD): 38.6 (9.4) y Race/ Ethnicity: NR Menopausal status: 7% nonestrogenic Obesity status: NR Mean BMI (SD): 23.9 (4.6) kg/m² Income level: NR Education level: NR Mean physical activity level: 36.1 PAI Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 47%, Vitamin D supplements: 56% Pregnant or lactating: NR</p>			
<p>PMID: 19419320 Meng 2009^{*23} Location/Country: Australia HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: Prospective cohort study Funding source: Nonprofit, government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 862</p> <p>Tertile 1: Protein intake <66 g/ d N: 287 % Female: 100% Mean Age (SD): 74.9 (2.5) y Race/ Ethnicity: 100% white origin Menopausal status: Postmenopausal</p>	<p>Tertile 1: Protein intake <66 g/d</p> <p>Baseline Protein Amount Mean (SD): 54.4 (9.1) g/d Carbohydrate Mean (SD): 146.8 (30.9) g/d Fat Mean (SD): 46.4 (13.3) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR</p>	<p>Protein Assessment Method: Participants completed a self- administered, quantitative FFQ. This FFQ has been designed to measure eating habits over the past 12-mo period and calibrated and validated according to the foods and on intake for a 12- mo period. The daily dietary intakes were derived from</p>	<p>Total Body BMC - Bone mineral content (total body)</p> <p>Measure/Method of Assessment: DXA (Hologic 4500A)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Obesity status: NR Mean BMI (SD): 26.4 (4.2) kg/m² Income level: NR Education level: NR Physical activity level: 466 (median kilojoules expended per day) Health status/ Comorbidities: Participants were excluded if they had a medical condition likely to influence 5-year survival. Medication use: Participants were excluded if they were taking bone active medications including calcium supplements, estrogen, bisphosphonates, and vitamin D. Supplement use: Participants were excluded if they were taking bone active medications including calcium supplements, estrogen, bisphosphonates, and vitamin D. Pregnant or lactating: NR</p> <p>Tertile 2: Protein intake 66-87 g/d N: 287 % Female: 100% Mean Age (SD): 75.0 (2.6) y Race/ Ethnicity: 100% white origin Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 26.7 (4.7) kg/m² Income level: NR</p>	<p>Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 2: Protein intake 66-87 g/d</p> <p>Baseline Protein Amount Mean (SD): 76.6 (6.2) g/d Carbohydrate Mean (SD): 186.4 (34.1) g/d Fat Mean (SD): 63.0 (13.3) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3: Protein intake >87 g/d</p> <p>Baseline Protein Amount Mean (SD): 110.9 (23.4) g/d Carbohydrate Mean (SD): 249.5 (61.9) g/d Fat Mean (SD): 85.1 (25.7) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 5 years</p>	<p>the questionnaire. Protein intake was assessed at baseline.</p>	

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Education level: NR Physical activity level: 530 (median kilojoules expended per day) Health status/ Comorbidities: Participants were excluded if they had a medical condition likely to influence 5-year survival. Medication use: Participants were excluded if they were taking bone active medications including calcium supplements, estrogen, bisphosphonates, and vitamin D. Supplement use: Participants were excluded if they were taking bone active medications including calcium supplements, estrogen, bisphosphonates, and vitamin D. Pregnant or lactating: NR</p> <p>Tertile 3: Protein intake >87 g/d N: 288 % Female: 100% Mean Age (SD): 74.7 (2.7) y Race/ Ethnicity: 100% white origin Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 27.3 (4.3) kg/m² Income level: NR Education level: NR Physical activity level: 614 (median kilojoules expended per day)</p>			

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Health status/ Comorbidities: Participants were excluded if they had a medical condition likely to influence 5-year survival. Medication use: Participants were excluded if they were taking bone active medications including calcium supplements, estrogen, bisphosphonates, and vitamin D. Supplement use: Participants were excluded if they were taking bone active medications including calcium supplements, estrogen, bisphosphonates, and vitamin D. Pregnant or lactating: NR</p>			
<p>PMID: 20442986 Misra 2011²⁴ Location/country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study design: Prospective cohort study Funding source: Government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 946</p> <p>Arm 1: No hip fracture N: 846 % Female: 58.6% Mean Age (SD): 75 (5.0) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Mean physical activity level: 33 PAI score Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Arm 2: Hip fracture</p>	<p>Arm 1: No hip fracture</p> <p>Baseline Protein Amount Mean (SD): 64.2 g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 2: Hip fracture</p> <p>Baseline Protein Amount Mean (SD): 63.6 g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study</p>	<p>Protein Assessment Method: FFQ was used to assess usual dietary intake by self-report. Total protein intake (g/day) was adjusted for total energy (from FFQ) to reduce error due to variation in total energy requirement, body size, and portion sizes, allowing interpretation of the effect of total protein intake. Protein intake was assessed at baseline.</p>	<p>Osteoporotic Fractures and Fracture Risk - Hip fracture</p> <p>Measure/Method of Assessment: Self-report</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	N: 100 % Female: 80.0% Mean Age (SD): 76 (5.2) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Mean physical activity level: 34 PAI score Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR	Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 16-17 y		
PMID: 36715763 Nakano 2023²⁵ Location/Country: Japan HDI: Very high Setting: NR Urban/ Rural: Urban Study design: Prospective cohort study Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 1,070 Arm 1: Whole cohort N: 1,070 % Female: 100% Mean Age (SD): 69.3 (10.9) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 22.6 (3.4) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Participants with critical or acute illness (e.g., terminal cancer, cardiovascular disease, or infectious diseases such as pneumonia) or secondary osteoporosis (e.g., due to primary	Arm 1: Whole cohort Baseline Protein Amount Mean (SD): 73.4 (15.1) g/d Carbohydrate Mean (SD): 200 (39) g/d Fat Mean (SD): 59.5 (12.2) g/d Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 5.8 y	Protein Assessment Method: Dietary nutrient intake was assessed by using an FFQ method for the prevention and management of osteoporosis (FFQPOP). The FFQPOP comprised a total of 28 food items. Subjects were asked to select the grade of intake frequency in the previous 1 month for each item. Nutrients and energy intakes were estimated by the frequency grade and relevant coefficients determined on the basis of the Standard Tables of Food Composition in Japan. Protein intake was assessed at baseline.	Osteoporotic Fractures and Fracture Risk - Fragility fracture (osteoporotic fracture) Measure/Method of Assessment: X-ray films

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>hyperparathyroidism, end-stage renal failure, or long-term steroid use) were excluded.</p> <p>Diabetes: 14.3%</p> <p>Dyslipidemia: 48.0%</p> <p>Hypertension: 58.1%</p> <p>Medication use: Participants under any kind of treatment for primary osteoporosis were included. Participants with long-term steroid use were excluded.</p> <p>Supplement use: NR</p> <p>Pregnant or lactating: NR</p>			
<p>PMID: 11914191</p> <p>Promislow 2002²⁶</p> <p>Location/Country: USA</p> <p>HDI: Very high</p> <p>Setting: Community dwelling</p> <p>Urban/ Rural: Urban</p> <p>Study design: Prospective cohort study</p> <p>Funding source: Government</p> <p>Risk of bias score: High</p>	<p>Study of: Adults</p> <p>Total sample N: 960</p> <p>Arm 1: Women</p> <p>N: 572</p> <p>% Female: 100%</p> <p>Mean Age (SD): 71.2 (8.7) y</p> <p>Race/ Ethnicity: Caucasian</p> <p>Menopausal status: Postmenopausal</p> <p>Obesity status: NR</p> <p>Mean BMI (SD): 24.6 (3.7) kg/m²</p> <p>Income level: NR</p> <p>Education level: NR</p> <p>Physical activity level: Exercise ≥3x per week: 70.9%</p> <p>Health status/ Comorbidities: NR</p> <p>Medication use: Thiazides: 24.7%</p> <p>Thyroid hormones: 21.0%</p> <p>Steroids: 3.9%</p> <p>Estrogen: 39.9%</p> <p>Supplement use: NR</p> <p>Pregnant or lactating: NR</p>	<p>Arm 1: Women</p> <p>Baseline Protein Amount</p> <p>Mean (SD): 71.2 (24.8) g/d</p> <p>Carbohydrate Mean (SD): NR</p> <p>Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study</p> <p>Mean (SD): NR</p> <p>Carbohydrate Mean (SD): NR</p> <p>Fat Mean (SD): NR</p> <p>Arm 2: Men</p> <p>Baseline Protein Amount</p> <p>Mean (SD): 73.8 (23.4) g/d</p> <p>Carbohydrate Mean (SD): NR</p> <p>Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study</p> <p>Mean (SD): NR</p> <p>Carbohydrate Mean (SD): NR</p> <p>Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p>	<p>Protein Assessment</p> <p>Method: Harvard-Willet diet assessment questionnaire was used to collect information on dietary intake. The questionnaire was self-administered and contained questions regarding portion size and consumption frequency of 128 common food items. Protein intake was assessed at baseline.</p>	<p>BMD of the Appendicular Skeleton - Bone mineral density (hip, total)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR, model 1000)</p> <p>BMD of the Appendicular Skeleton - Bone mineral density (femoral neck)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR, model 1000)</p> <p>BMD of the Axial Skeleton - Bone mineral density (lumbar spine)</p> <p>Measure/Method of Assessment: DXA (Hologic QDR, model 1000)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Arm 2: Men N: 388 % Female: 0% Mean Age (SD): 70.0 (8.5) y Race/ Ethnicity: Caucasian Menopausal status: NA Obesity status: NR Mean BMI (SD): 26.4 (3.4) kg/m² Income level: NR Education level: NR Physical activity level: Exercise ≥3x per week: 78.9% Health status/ Comorbidities: NR Medication use: Thiazides: 15.0% Thyroid hormones: 4.4% Steroids: 2.1% Supplement use: NR Pregnant or lactating: NA</p>	<p>Energy Balance status: Eucaloric</p> <p>Study duration: 4 y</p>		
<p>PMID: 33847345 Rivera-Paredes 2021²⁷ Location/Country: Mexico HDI: High Setting: Community dwelling Urban/ Rural: Urban Study design: Prospective cohort study Funding source: Government Risk of bias score: Moderate</p>	<p>Study of: Adults Total sample N: NR</p> <p>Arm 1: Whole Cohort N: NR % Female: 100% Mean Age (SD): 57 y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: 26.5% Mean BMI (SD): 27.1 kg/m² Income level: NR Education level: NR Mean physical activity level: 13.0 (leisure time physical activity, min/d) Health status/ Comorbidities: NR</p>	<p>Arm 1: Whole Cohort</p> <p>Baseline Protein Amount Median (IQR): 66.4 (51.1-86.0) g/d Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Protein Amount at the end of the study Median (IQR): 50.1 (37.8- 66.9) g/d Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Protein type/source: Mixed</p>	<p>Protein Assessment Method: A semi-quantitative FFQ was used to collect data on the consumption frequency of 116 food items during the previous year. Average daily nutrient intake was calculated by multiplying the frequency of consumption of each food by the nutrient content. Protein intake was assessed at baseline.</p>	<p>BMD of the Axial Skeleton - Bone mineral density (L1-L4 (lumbar spine))</p> <p>Measure/Method of Assessment: DXA Lunar DPX NT instrument (Lunar Radiation Corp.)</p> <p>BMD of the Appendicular Skeleton - Bone mineral density (femoral neck)</p> <p>Measure/Method of Assessment: DXA Lunar DPX NT instrument (Lunar Radiation Corp.)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	Medication use: Hormone replacement therapy: 7.8% Supplement use: 25.2% dietary supplement Pregnant or lactating: NA	Energy balance status: Eucaloric Study duration: 6.4 y		BMD of the Appendicular Skeleton - Bone mineral density (hip, total) Measure/Method of Assessment: DXA Lunar DPX NT instrument (Lunar Radiation Corp.)
PMID: 20662074 Sahni 2010 ²⁸ Location/Country: USA HDI: Very high Setting: NR Urban/ Rural: NR Study design: Prospective cohort study Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 3,656 Arm 1: Men N: 1,725 % Female: 0% Mean Age (SD): 55.3 (9.9) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 28.1 (4.1) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 13.0% Pregnant or lactating: NA Arm 2: Women N: 1,931 % Female: 100% Mean Age (SD): 54.9 (9.8) y Race/ Ethnicity: NR Menopausal status: 68.9% postmenopausal Obesity status: NR	Arm 1: Men Baseline Protein Amount Mean (SD): 79.0 (27) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Arm 2: Women Baseline Protein Amount Mean (SD): 75.7 (27) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 7-10 y	Protein Assessment Method: Usual dietary intake was assessed with the semi-quantitative 126-item Willett FFQ. Intakes of total protein (g/day), plant protein (g/day), and animal protein (g/day) were assessed using the food list section of the FFQ. Animal/plant protein intake ratio was calculated. Protein intake was assessed at baseline.	Osteoporotic Fractures and Fracture Risk - Hip fracture Measure/Method of Assessment: Self-report & confirmed by review of medical records

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	Mean BMI (SD): 26.8 (5.5) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 29.2% Pregnant or lactating: NR			
PMID: 24168918 Sahni 2014 ²⁹ Location/Country: USA HDI: Very high Setting: NR Urban/ Rural: NR Study design: Prospective cohort study Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 1,175 Arm 1: Men N: 495 % Female: 0% Mean Age (SD): 61 (9.0) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 28.8 (4.4) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: Osteoporosis medication: 0.2% Supplement use: 24% used Calcium supplements: 24% Vitamin D supplements: 40% Pregnant or lactating: NA Arm 2: Women N: 680 % Female: 100% Mean Age (SD): 60 (9.2) y	Arm 1: Men Baseline Protein Amount Mean (SD): 81 (28) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Arm 2: Women Baseline Protein Amount Mean (SD): 77 (26) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein type/source: Mixed Energy balance status: Eucaloric	Protein Assessment Method: Usual dietary intake was assessed with a semi-quantitative, 126-item Willett FFQ. Intakes of total protein (g/d) were assessed using the food list section of the FFQ. Protein intake was assessed at baseline.	BMD of the Appendicular Skeleton - Bone mineral density (hip, total) Measure/Method of Assessment: DXA (LUNAR DPX-L) BMD of the Axial Skeleton - Bone mineral density (lumbar spine) Measure/Method of Assessment: DXA (LUNAR DPX-L)

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	Race/ Ethnicity: NR Menopausal status: 86% postmenopausal Obesity status: NR Mean BMI (SD): 27.4 (5.6) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: Osteoporosis medication: 3.6% Supplement use: Calcium supplements: 56% Vitamin D supplements: 53% Pregnant or lactating: NR	Study duration: 1.5-8 y		
PMID: 11124760 Sellmeyer 2001 ³⁰ Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: Prospective cohort study) Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 1,035 Tertile 1: Low ratio of animal to vegetable protein N: NR % Female: 100% Mean Age (SD): 74.3 (5.4) y Race/ Ethnicity: 100% white Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 25.6 (4.6) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR	Tertile 1: Low ratio of animal to vegetable protein Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): 42.0 (15.9) g Carbohydrate Mean (SD): NR Fat Mean (SD): NR Tertile 2: Medium ratio of animal to vegetable protein Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR	Protein Assessment Method: Nutrient intake data were obtained from a 24-h dietary recall and an FFQ. The 24-h dietary recall consisted in registering all the meals and beverages consumed during the 24 h before the subject awoke on the day of the interview, assessing, for each food item, the portion sizes and their weight correspondence according to a book of photographs. Food intake data were estimated from a detailed FFQ, the frequency of consumption of 148 foods and nonalcoholic beverages for each of the three main meals and three between-meals snacks was recorded	BMD of the Appendicular Skeleton - Bone mineral density (hip and subregions) Measure/Method of Assessment: DXA (Hologic QDR-1000, version 6.10) Osteoporotic Fractures and Fracture Risk - Hip fracture Measure/Method of Assessment: Self-report & confirmed with radiographs

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Tertile 2: Medium ratio of animal to vegetable protein N: NR % Female: 100% Mean Age (SD): 73.2 (4.9) y Race/ Ethnicity: 100% white Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 26.5 (4.7) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 3: High ratio of animal to vegetable protein N: NR % Female: 100% Mean Age (SD): 72.5 (4.5) y Race/ Ethnicity: 100% white Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 26.7 (4.9) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Protein Amount at the end of the study Mean (SD): 49.2 (16.9) g Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3: High ratio of animal to vegetable protein</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): 58.3 (20.0) g Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 7 y</p>	<p>in 11 classes. Protein intake was assessed at baseline.</p>	
<p>PMID: 33677533 Weaver 2021³¹</p>	<p>Study of: Adults Total sample N: 2,160</p>	<p>Tertile 1: Protein intake <13% of energy</p>	<p>Protein Assessment Method: Participants completed a 108-item,</p>	<p>BMD of the Appendicular Skeleton - Bone mineral density (hip, total)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
<p>Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study design: Prospective cohort study Funding source: Government Risk of bias score: High</p>	<p>Tertile 1: Protein intake <13% of energy N: 718 % Female: 47.0% Mean Age (SD): 73.5 (2.9) y Race/ Ethnicity: Black: 47.0% Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.1 (4.7) kg/m² Income level: NR Education level: Less than high school: 23.3% High school: 35.1% Postsecondary education: 41.7% Physical activity level: 0 min walking/wk: 43.9% 1–149 min walking/wk: 29.3% >150 min walking/wk: 26.8% Health status/ Comorbidities: Participants free of life-threatening illness were included Medication use: Osteoporosis medication: 3.4% Supplement use: 15.0% Calcium supplements: 15.0% Vitamin D supplements: 6.6% Pregnant or lactating: NR</p> <p>Tertile 2: Protein intake 13-15% of energy N: 703 % Female: 52.2% Mean Age (SD): 73.4 (2.8) y</p>	<p>Baseline Protein Amount Mean (SD): 12 (1) % of energy Carbohydrate Mean (SD): 55 (8) % of energy Fat Mean (SD): 34 (7) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 2: Protein intake 13-15% of energy</p> <p>Baseline Protein Amount Mean (SD): 14 (1) % of energy Carbohydrate Mean (SD): 53 (8) % of energy Fat Mean (SD): 34 (7) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3: Protein intake >15% of energy</p> <p>Baseline Protein Amount Mean (SD): 18 (2) % of energy Carbohydrate Mean (SD): 52 (8) % of energy Fat Mean (SD): 32 (8) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR</p>	<p>interviewer-administered modified version of the FFQ. Wood blocks, food models, standard kitchen measures, and flash cards were used by trained interviewers to assist participants in estimating food portion sizes. Energy intake and macronutrient and micronutrient content were calculated from the FFQ by Block Dietary Data Systems (Berkeley, CA). Total protein intake, as well as the source of protein (e.g., animal or vegetable), was computed. Protein intake was assessed one year from baseline.</p>	<p>Measure/Method of Assessment: DXA (Hologic 4500A, software v.9.03)</p> <p>BMD of the Appendicular Skeleton - Bone mineral density (femoral neck)</p> <p>Measure/Method of Assessment: DXA (Hologic 4500A, software v.9.03)</p> <p>aBMD of the total body – Areal bone mineral density (total body)</p> <p>Measure/Method of Assessment: DXA (Hologic 4500A, software v.9.03)</p> <p>Osteoporotic Fractures and Fracture Risk - Fragility fracture (low-trauma)</p> <p>Measure/Method of Assessment: Self-report & confirmed with radiographs</p> <p>Osteoporotic Fractures and Fracture Risk - Incident hip fracture</p> <p>Measure/Method of Assessment: Self-report & confirmed with radiographs</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	<p>Race/ Ethnicity: Black: 52.2% Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.0 (4.4) kg/m² Income level: NR Education level: Less than high school: 21.7% High school: 31.2% Postsecondary education: 47.1% Physical activity level: 0 min walking/wk: 40.1% 1–149 min walking/wk: 33.8% >150 min walking/wk: 26.2% Health status/ Comorbidities: Participants free of life-threatening illness were included Medication use: Osteoporosis medication: 5.2% Supplement use: Calcium supplements: 19.7% Vitamin D supplements: 9.8% Pregnant or lactating: NR</p> <p>Tertile 3: Protein intake >15% of energy N: 739 % Female: 55.3% Mean Age (SD): 73.7 (2.9) y Race/ Ethnicity: Black: 55.3% Menopausal status: NR Obesity status: NR</p>	<p>Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 5 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of assessment)	Outcome (Measures and methods assessment)
	Mean BMI (SD): 27.5 (4.8) kg/m ² Income level: NR Education level: Less than high school: 19.8% High school: 33.6% Postsecondary education: 46.6% Physical activity level: 0 min walking/wk: 37.0% 1–149 min walking/wk: 30.3% >150 min walking/wk: 32.7% Health status/ Comorbidities: Participants free of life-threatening illness were included. Medication use: Osteoporosis medication: 5.2% Supplement use: Calcium supplements: 24.0% Vitamin D supplements: 10.5% Pregnant or lactating: NR			

Abbreviations: BMC = bone mineral content; BMD = bone mineral density; BMI = body mass index; CT = computed tomography; CVD = cardiovascular disease; d = day; DXA = Dual-energy x-ray absorptiometry; e.g. = exempli gratia; FFQ = food frequency questionnaire; FFQPOP = food frequency questionnaire method for the prevention and management of osteoporosis; HDI = human development index; g = grams; g/100g = grams per 100 grams; g/cm² = grams per centimeter squared; g/d = grams per day; h = hour; IU = international units; IQR = interquartile range; kcal = kilocalories; kg/m² = kilograms per meter squared; METs = metabolic equivalents; min/d = minutes per day; mg = milligrams; mL = milliliter; MPB = milk based protein; MR= meal replacement; NA = not applicable; NR = not reported; PA = physical activity; PAI = physical activity index; PASE = Physical activity scale for the elderly; PMID = PubMed Identification Number; RCT = randomized controlled trail; RoB = Risk of Bias; SD = standard deviation; SE = standard error; SEM = standard error of the mean; µg/L = micrograms per liter; USA = United States of America; wk = week; vBMD = volumetric bone mineral density; y = year

Note:* Studies overlap KQs

Table C3. Evidence table for Kidney Disease Randomized Controlled Trials

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>PMID: 20578205 Flechner-Mors 2010³² Location/Country: Germany HDI: Very high Setting: Outpatient clinic Urban/Rural: NR Study design: RCT (parallel) Funding source: Industry, academic Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 110</p> <p>Intervention: High Protein N: 55 % Female: 78.2% Mean Age (SD): 49.3 (12.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: Obese Mean BMI (SD): 36.2 (4.4) kg/m² Income level NR Education level: NR Physical activity level: Received instructions to maintain their usual physical activity during the study and not to undertake any new exercise programs, but exercise was not monitored Health status/ Comorbidities: Included: Those that met the criteria for metabolic syndrome Medication use: Exclude: anti-obesity medications Supplement use: NR Pregnant or lactating: Excluded</p> <p>Comparator: Conventional Diet N: 55 % Female: 81.2%</p>	<p>Intervention: High Protein</p> <p>Intended Protein Amount: 1.34 g/kg/d; 30% of energy Carbohydrate: 40% of energy Fat: 30% of energy</p> <p>Baseline Protein Amount Mean (SD):18.0 (4.9) % of energy; 72.7 (24.3) g/d Carbohydrate Mean (SD): 46.7 (9.4) % of energy; 194 (73) g/d Fat: 35.2 (7.6) % of energy; 64 (25) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 30.0 (7.0) % of energy; 92.2 (14.8) g/d Carbohydrate Mean (SD): 36.9 (7.9) % of energy; 119 (45) g/d Fat Mean (SD): 29.9 (5.7) % of energy; 42 (13) g/d</p> <p>Dietary Protein Intake Compliance (%): 56.3%</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Comparator: Conventional Diet</p> <p>Intended Protein Amount: 0.8 g/kg/d; 15% energy</p>	<p>Intervention: High Protein</p> <p>How protein was administered: First 3 months: Consumed two protein-enriched meal replacements, one conventional meal, and two snacks as either a protein bar or a low-fat curd with fruit.</p> <p>After the first 3 months: Consumed one protein-enriched meal replacement, two meals, and two snacks</p> <p>Protein Assessment Method: Subjects kept 3-day food records at baseline, 3 months, 6 months, 9 months, and 12 months. Food quantities were recorded using standard household measures, and a trained assessment dietician reviewed the food records in person. Nutrient calculations were carried out using the PRODI program which is based on German food-composition tables.</p>	<p>Kidney Function — Blood urea nitrogen</p> <p>Measure/Method of Assessment: Venous blood samples were collected every three months to measure blood urea nitrogen and serum creatinine using standard assays.</p> <p>Kidney Function — Serum creatinine</p> <p>Measure/Method of Assessment: Venous blood samples were collected every three months to measure blood urea nitrogen and serum creatinine using standard assays.</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Mean Age (SD): 50 (13) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: Obese Mean BMI (SD): 36.3 (5.0) kg/m² Income level NR Education level: NR Physical activity level: Received instructions to maintain their usual physical activity during the study and not to undertake any new exercise programs, but exercise was not monitored Health status/ Comorbidities: Included: Those that met the criteria for metabolic syndrome Medication use: Exclude: anti-obesity medications Supplement use: NR Pregnant or lactating: Excluded</p>	<p>Carbohydrate: 30% energy Fat: 55% energy</p> <p>Baseline Protein Amount Mean (SD): 17.0 (4.7) % of energy; 66.4 (22.7) g/d Carbohydrate Mean (SD): 48.2 (9.4) % of energy; 188 (64) g/d Fat Mean (SD): 34.6 (7.3) % of energy; 60 (26) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 21.4 (7.4) % of energy; 65.7 (14.7) g/d Carbohydrate Mean (SD): 47.6 (7.5) % of energy; 154 (44) g/d Fat: 29.6 (5.7) % of energy; 44 (16) g/d</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Study duration: 12 months</p>	<p>Dietary Protein Intake Compliance: Food records yielded data that revealed adherence to the dietary recommendations during the study</p> <p>Comparator: Conventional Diet</p> <p>How protein was administered: First 3 months: Consumed three meals and two snacks with no replacements</p> <p>After 3 months: Consumed one standard meal replacement, two meals, and two snacks per day</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>PMID: 18371214 Frestedt 2008³³ Location/Country: USA HDI: Very high Setting: Community dwelling Urban/Rural: NR Study design: RCT (parallel) Funding source: Industry Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 59</p> <p>Intervention: Prolibra N: 31 % Female: NR Mean Age (SE): 43.6 (1.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: Obese Mean BMI (SE): 35.7 (0.7) kg/m² Income level NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Comparator: Placebo N: 28 % Female: NR Mean Age (SE): 42 (1.2) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: Obese Mean BMI (SE): 35.4 (0.7) kg/m² Income level NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Intervention: Prolibra</p> <p>Intended Protein Amount: Supplement 20 g of protein/d (1-10g protein supplement twice daily); 15% of energy Carbohydrate: 55% of energy Fat: 30% of energy</p> <p>Baseline Protein Amount Mean (SD): 73 (3) g/d; 0.74 g/kg/d Carbohydrate Mean (SD): 222 (11) g/d Fat Mean (SD): 75 (5) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 0.81 g/kg/d (with supplement); 0.60 g/kg/d and 57 (3) g/d (w/o supplement) Carbohydrate Mean (SD): 178 (8) g/d (w/o supplement) Fat Mean (SD): 49 (3) g/d (w/o supplement)</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Animal; whey protein</p> <p>Energy balance status: Hypocaloric</p> <p>Comparator: Placebo</p> <p>Intended Protein Amount: 15% of energy Carbohydrate: 55% of energy Fat: 30% of energy</p>	<p>Intervention: Prolibra</p> <p>How protein was administered: One Prolibra supplement before breakfast and one before dinner. Each supplement contained 10 g of protein. Subjects were assigned a diet plan with a certain number of servings for various food groups similar to the standard paradigm set by the American Heart Association.</p> <p>Protein Assessment Method: Total protein in Prolibra was measuring using Kjeldahl (AOAC 945.01). Subjects completed diet diaries on at least 5 days each month.</p> <p>Dietary Protein Intake Compliance: Compliance was assessed by supplement count and diet diary review. Participants were also contacted by telephone between visits to review diet and supplement compliance.</p> <p>Comparator: Placebo</p>	<p>Kidney Function — Blood urea nitrogen</p> <p>Measure/Method of Assessment: Venous blood samples were collected from each subject at weeks 0 and 12 to measure blood urea nitrogen.</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
		<p>Baseline Protein Amount Mean (SD): 74 (4) g/d; 0.76 g/kg/d Carbohydrate Mean (SD): 211 (10) g/d Fat Mean (SD): 71 (5) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 0.61 g/kg/d (with supplement); 58 (2) g/d (w/o supplement) Carbohydrate Mean (SD): 182 (9) g/d (w/o supplement) Fat Mean (SD): 47 (3) g/d (w/o supplement)</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Study duration: 12 weeks</p>	<p>How protein was administered: Subjects received an iso-caloric beverage containing maltodextrin. Subjects were assigned a diet plan with a certain number of servings for various food groups similar to the standard paradigm set by the American Heart Association.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>PMID: 19167797 Jacobs 2009³⁴ Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: RCT (parallel) Funding Source: Government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 378</p> <p>Intervention: DASH Diet N: 127 % Female: 50% Mean Age (SD): 44.2 (10.2) y Race/ Ethnicity: White: 35% African American: 60% Other: 5% Menopausal status: NR Obesity status: NR Mean BMI (SD): 28.5 (4.0) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Considered healthy but with untreated prehypertension or stage I hypertension (32% hypertensive). Those with diabetes and decreased glomerular filtration rate were excluded Medication use: Use of medications that could affect blood pressure were excluded; no other medication use was reported Supplement use: Use of nutritional supplements that could affect blood pressure were excluded; no other nutritional</p>	<p>Intervention: DASH Diet</p> <p>Intended Protein Amount: 17.9% of energy Carbohydrate: 56.5% of energy Fat: 25.6% of energy</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate: NR Fat: NR</p> <p>Actual Protein Amount at the end of the study: 17.8% of energy Carbohydrate: 56.5% of energy Fat: 25.6% of energy</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Comparator 1: Fruit/vegetable diet</p> <p>Intended Protein Amount: 15.1% of energy Carbohydrate: 49.2% of energy Fat: 35.7% of energy</p> <p>Baseline Protein Amount: NR Carbohydrate: NR Fat: NR</p>	<p>Intervention: DASH Diet</p> <p>How protein was administered: NR</p> <p>Protein assessment method: NR</p> <p>Dietary Protein Intake Compliance: NR</p> <p>Comparator 1: Fruit/vegetable diet</p> <p>How protein was administered: NR</p> <p>Protein assessment method: NR</p> <p>Dietary Protein Intake Compliance: NR</p> <p>Comparator 2: Control diet</p> <p>How protein was administered: NR</p> <p>Protein assessment method: NR</p> <p>Dietary Protein Intake Compliance: NR</p>	<p>Proteinuria — Urinary albumin excretion</p> <p>Measure/Method of Assessment: In 24-hour urine samples, albumin concentration was measured by a nephelometer with an enhanced sensitivity and a coefficient of variation in 50 masked duplicate samples; albumin excretion rate was computed as the urinary albumin concentration (mg/L) times the urine volume (L) times 24 hours/collection hours.</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>supplement use was reported Pregnant or lactating: Excluded if current or planned pregnancy prior to end of study or breast-feeding</p> <p>Comparator 1: Fruit/vegetable diet N: 127 % Female: 49% Mean Age (SD): 45.7 (10.6) y Race/ Ethnicity: White: 38% African American: 57% Other: 5% Menopausal status: NR Obesity status: NR Mean BMI (SD): 28.3 (3.9) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Considered healthy but with untreated prehypertension or stage I hypertension (32% hypertensive). Those with diabetes and decreased glomerular filtration rate were excluded Medication use: Use of medications that could affect blood pressure were excluded; no other</p>	<p>Actual Protein Amount at the end of the study: 15.1% of energy Carbohydrate: 49.2% of energy Fat: 35.7% of energy</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Comparator 2: Control diet</p> <p>Intended Protein Amount: 13.8% of energy Carbohydrate: 50.5% of energy Fat: 35.7% of energy</p> <p>Baseline Protein Amount: NR Carbohydrate: NR Fat: NR</p> <p>Actual Protein Amount at the end of the study: 14.0% of energy Carbohydrate: 50.5% of energy Fat: 35.7% of energy</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: mixed</p>		

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>medication use was reported Supplement use: Use of nutritional supplements that could affect blood pressure were excluded; no other nutritional supplement use was reported Pregnant or lactating: Excluded if current or planned pregnancy prior to end of study or breast-feeding</p> <p>Comparator 2: Control diet N: 127 % Female: 45% Mean Age (SD): 49 (11.1) y Race: White: 38% African American: 57% Other: 5% Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.9 (3.8) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Considered healthy but with untreated prehypertension or stage I hypertension (32% hypertensive). Those with diabetes and decreased</p>	<p>Study Duration/Follow up: 8 weeks</p>		

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	glomerular filtration rate were excluded Medication use: Use of medications that could affect blood pressure were excluded; no other medication use was reported Supplement use: Use of nutritional supplements that could affect blood pressure were excluded; no other nutritional supplement use was reported Pregnant or lactating: Excluded if current or planned pregnancy prior to end of study or breast-feeding			
PMID: 23219108 Juraschek 2013 ³⁵ Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study Design: RCT (crossover) Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 164 Overall N: 164 % Female: 45% Mean Age (SD): 53.5 (10.8) y Race/ Ethnicity: African American: 55% Non-Hispanic White: 40% Other: 5% Menopausal status: NR Obesity status: NR Mean BMI (SD): 30.2 (6.1) kg/m ² Income level: NR Education level: Education less than or equal to a HS diploma: 20.1%	Intervention: Protein diet Intended Protein Amount: 25% of energy Carbohydrate: 48% of energy Fat: 27% of energy Baseline Protein Amount: NR Carbohydrate: NR Fat: NR Actual Protein Amount at the end of the study: 25% of energy Carbohydrate: 48% of energy Fat: 27% of energy Dietary Protein Intake Compliance (%): NR. Overall compliance in the trial was 83.8%.	Intervention: Protein diet How protein was administered: A 7-day menu cycle at 5 caloric levels was developed for each diet. Participants were provided all of their food, which was prepared in research kitchens. For each day of controlled feeding, participants completed a diary in which they indicated whether they ate any nonstudy foods and whether they did not eat all study foods. Protein Assessment Method: For each menu	Kidney function — Serum creatinine Measure/Method of Assessment: Serum creatinine was measured from serum specimens using standardized laboratory assays. Kidney function — eGFR Measure/Method of Assessment: eGFR was calculated using the CKD Epidemiology Collaboration (CKD-EPI) cystatin C equation Creatinine-based eGFR was calculated using the CKD-EPI creatinine equation. eGFR measurement (with or without race): with race

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Physical activity level: Participants encouraged to maintain the same activity level Health status/Co-morbidities: Generally healthy Medication use: NR; excluded if taking medications that affect blood pressure or blood lipid levels Supplement use: Excluded if unwilling to stop taking vitamin and mineral supplements Pregnant or lactating: NR</p>	<p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Comparator 1: Carbohydrate diet</p> <p>Intended Protein Amount: 15% of energy Carbohydrate: 58% of energy Fat: 27% of energy</p> <p>Baseline Protein Amount: NR Carbohydrate: NR Fat: NR</p> <p>Actual Protein Amount at the end of the study: 15% of energy Carbohydrate: 58% of energy Fat: 27% of energy</p> <p>Dietary Protein Intake Compliance (%): NR. Overall compliance in the trial was 83.8%.</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Comparator 2: Unsaturated diet</p> <p>Intended Protein Amount: 15% of energy Carbohydrate: 48% of energy Fat: 37% of energy</p>	<p>of each diet, sample validation meals were prepared and composited. The nutrient profile of each composite was analyzed for all target nutrients at Covance Laboratories</p> <p>Dietary Protein Intake Compliance: Participants kept a diary in which they listed their consumption of nonprotocol foods; in other words, any foods not given by study staff.</p> <p>Comparator 1: Carbohydrate diet</p> <p>How protein was administered: A 7-day menu cycle at 5 caloric levels was developed for each diet. Participants were provided all of their food, which was prepared in research kitchens. For each day of controlled feeding, participants completed a diary in which they indicated whether they ate any nonstudy foods and whether they did not eat all study foods.</p> <p>Protein Assessment Method: Same as above</p>	

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
		<p>Baseline Protein Amount: NR Carbohydrate: NR Fat: NR</p> <p>Actual Protein Amount at the end of the study: 15% of energy Carbohydrate: 48% of energy Fat: 37% of energy</p> <p>Dietary Protein Intake Compliance (%): NR. Overall compliance in the trial was 83.8%.</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 6 weeks</p> <p>Crossover details: Number of intakes per participant: 3 Total intakes: 468 Wash out period: 2-4 weeks</p>	<p>Dietary Protein Intake Compliance: Participants kept a diary in which they listed their consumption of nonprotocol foods; in other words, any foods not given by study staff.</p> <p>Comparator 2: Unsaturated diet</p> <p>How protein was administered: A 7-day menu cycle at 5 caloric levels was developed for each diet. Participants were provided all of their food, which was prepared in research kitchens. For each day of controlled feeding, participants completed a diary in which they indicated whether they ate any nonstudy foods and whether they did not eat all study foods.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Participants kept a diary in which they listed their consumption of nonprotocol foods; in other words, any foods not given by study staff.</p>	
PMID: 25844619 Kerstetter 2015*#⁵	Study of: Adults Total sample N: 208	Intervention: High Protein	Intervention: High Protein	Kidney Function — eGFR Measure/Method of Assessment:

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>Location/Country: USA HDI: Very high Setting: NR Urban/ Rural: NR Study design: RCT (parallel) Funding source: Government, academic Risk of bias score: High</p>	<p>Intervention: High Protein N: 106 % Female: 84% Mean Age (SD): 69.9 (6.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.1 (3.4) kg/m² Income level: NR Education level: NR Mean physical activity level score (SD): 6.7 (2.1) Health status/ Comorbidities: Healthy older adults Medication use: Excluded if using long-term chemotherapeutic drugs, aromatase inhibitors or tamoxifen, methotrexate, phenytoin, phenobarbital or inhaled corticosteroids (greater than 800 ug/day), actively being treated for leukemia or multiple myeloma, a change in thyroid medications, medications known to affect calcium metabolism or use of proton pump inhibitors twice daily Supplement use: Daily multivitamin mineral supplement (contained 400 IU of vitamin D); Ca carbonate supplement (300 mg tablets) Pregnant or lactating: NR</p>	<p>Intended Protein Amount: 40 g of protein from the supplement; total daily protein goal NR Carbohydrate: Test food protein NR Fat: Test food protein NR</p> <p>Baseline Protein Amount Least Square Mean (SEM): 73.8 (1.9) g/d Carbohydrate Least Square Mean (SEM): 214.1 (5.2) g/d Fat Least Square Mean (SEM): 59.4 (2.1) g/d</p> <p>Actual Protein Amount at the end of the study Least Square Mean (SEM): 90.7 (3.3) g/d Carbohydrate Least Square Mean (SEM): 196.9 (6.6) g/d Fat Least Square Mean (SEM): 55.6 (2.0) g/d</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Animal; whey supplement</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Low Protein</p> <p>Intended Protein Amount: Test food protein NR Carbohydrate: Test food protein NR Fat: Test food protein NR</p>	<p>How protein was administered: Participants received a dietary whey protein supplement (protein group; Provon 290; Glambia Nutritionals) that was closely matched for composition, color, kilocalories, sodium, potassium, phosphorus, fiber, and calcium.</p> <p>Protein Assessment Method: Participants completed a 3-day food record prior to baseline, 6 months, and 18 months and were analyzed using the ESHA Food Processor software program (ESHA Research; version 10.1.0).</p> <p>Dietary Protein Intake Compliance: Urinary area was a compliance measure.</p> <p>Comparator: Low Protein</p> <p>How protein was administered: Participants received a maltodextrin supplement Maltrin M100; Grain Processing Corp) that was closely matched for composition, color, kilocalories, sodium,</p>	<p>Serum creatinine measured using an ACE Wasserman autoanalyzer, eGFR calculated from serum creatinine, age, sex, and race using the National Kidney Foundation online calculator.</p> <p>eGFR measurement (with or without race): with race</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Comparator: Low Protein N: 102 % Female: 87.3% Mean Age (SD): 70.5 (6.4) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.4 (4.0) kg/m² Income level: NR Education level: NR Mean physical activity level score (SD): 6.8 (1.9) Health status/ Comorbidities: Healthy older adults Medication use: Excluded if using long-term chemotherapeutic drugs, aromatase inhibitors or tamoxifen, methotrexate, phenytoin, phenobarbital or inhaled corticosteroids (greater than 800 ug/day), actively being treated for leukemia or multiple myeloma, a change in thyroid medications, medications known to affect calcium metabolism or use of proton pump inhibitors twice daily Supplement use: Daily multivitamin mineral supplement (contained 400 IU of vitamin D); Ca carbonate supplement (300 mg tablets) Pregnant or lactating: NR</p>	<p>Baseline Protein Amount Least Square Mean (SEM): 72.9 (1.8) g/d; 1.06 (0.03) g/kg/d (total daily) Carbohydrate Least Square Mean (SEM): 206.2 (5.8) g/d (total daily) Fat Least Square Mean (SEM): 61.3 (2.5) g/d (total daily)</p> <p>Actual Protein Amount at end of the study Least Square Mean (SEM): 72.7 (2.4) g/d; 1.05 (0.04) g/kg/d (total daily) Carbohydrate Least Square Mean (SEM): 229.0 (9.5) g/d (total daily) Fat Least Square Mean (SEM): 58.8 (2.4) g/d (total daily)</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 18 months</p>	<p>potassium, phosphorus, fiber, and calcium.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>PMID: 21194471 Li 2010⁶ Location/Country: United States HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: RCT (parallel) Funding source: Industry Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 85</p> <p>Intervention: High Protein N: 44 % Female: 81.8% Mean Age (SD): 48.9 (11.8) y Race/ Ethnicity: Asian: 9.1% Black: 20.5% Caucasian: 59.1% Hispanic: 9.1% Other: 2.2% Menopausal status: NR Obesity status: Obese Mean BMI (SD): 34.7 (6.8) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Inclusion: good health history; participants reported to be obese; Exclusion type 2 diabetes or glucose intolerance Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Comparator: Normal Protein N: 42 % Female: 63.4% Mean Age (SD): 49.7 (9.1) y Race/ Ethnicity: Asian: 2.4%</p>	<p>Intervention: High Protein</p> <p>Intended Protein Amount: 2.2 g per kg of lean body mass; 30% of energy Carbohydrate: 40% of energy Fat: 30% total energy</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Meal replacement protein: NR, Diet: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Normal Protein</p> <p>Intended Protein Amount: 1.1 g per kg of lean body mass (15% total energy) Carbohydrate: 55% total energy Fat: 30% total energy</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR</p>	<p>Intervention: High Protein</p> <p>How protein was administered: Participants received isocaloric MR (Formula 1, Herbalife Intl., Los Angeles) with a protein supplement (Performance Protein Powder, Herbalife Intl., Los Angeles)</p> <p>Protein Assessment Method: Protein was assessed through qualitative food logs and reviewed with dietitians at follow-ups. Protein intake was measured at each follow-up visit; baseline, week 2, and months 1, 2, 3, 6, 9, 12.</p> <p>Dietary Protein Intake Compliance: No special efforts were made to assess compliance.</p> <p>Comparator: Normal Protein</p> <p>How protein was administered: Participants received the isocaloric MR (Formula 1, Herbalife Intl., Los Angeles) with matched carbohydrate placebo containing maltodextrin and flavoring</p>	<p>Kidney Function — Serum creatinine</p> <p>Measure/Method of Assessment: Standard laboratory blood serum assay methods</p> <p>Kidney Function — Urinary urea nitrogen</p> <p>Measure/Method of Assessment: Twenty-four hour urine samples were collected for urinary urea nitrogen. Urinary urea nitrogen was measured with an enzymatic method.</p> <p>Kidney Function — Creatinine clearance</p> <p>Measure/Method of Assessment: Twenty-four hour urine samples and standard laboratory blood serum assay methods</p> <p>Kidney Function — Serum urea nitrogen</p> <p>Measure/Method of Assessment: Standard laboratory blood serum assay methods</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	Black: 19.5% Caucasian: 68.3% Hispanic: 4.9% Other: 4.9% Menopausal status: NR Obesity status: Obese Mean BMI (SD): 34.3 (10.3) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Inclusion: good health history; participants reported to be obese; Exclusion type 2 diabetes or glucose intolerance Medication use: NR Supplement use: NR Pregnant or lactating: NR	Fat Mean (SD): NR Actual Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Dietary Protein Intake Compliance (%): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 12 months	Protein Assessment Method: Same as above Dietary Protein Intake Compliance: Same as above	
PMID: 33871558 Murphy 2021 ^{*36} Location/Country: Ireland HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study design: RCT (parallel) Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 107 Intervention 1: Leucine-enriched Protein N: 38 % Female: 52.6% Mean Age (SD): 70 (5) y Race/Ethnicity: 100% White Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.8 (3.4) kg/m ² Income level: NR Education level: NR Mean physical activity level (SD): 8354 (4125) steps/day	Intervention 1: Leucine-enriched Protein Intended Protein Amount: 21.2 g in supplemental protein per day; total intake goals NR Carbohydrate: NR Fat: NR Baseline Protein Amount Mean (SD): 84 (26) g/d; 17.1 (3.9) % of energy Carbohydrate Mean (SD): 226 (78) g/d; 45.0 (9.7) % of energy Fat Mean (SD): 82 (32) g/d; 36.3 (7.7) % of energy Actual Protein Amount at the end of the study	Intervention 1: Leucine-enriched Protein How protein was administered: Two supplements daily equaling 21.2 g protein per day (including 6.2 g leucine); one was consumed before breakfast and one before their second light meal of the day with habitual diet Protein Assessment Method: Dietary intake was assessed via a 24-h recall using the 5-step multiple-pass method at	Kidney Function — eGFR Measure/Method of Assessment: Serum creatinine measured using a chemical autoanalyzer with standardized assays. eGFR was derived using CKD Epidemiology Collaboration (CKD-EPI) cystatin C equation. eGFR measurement (with or without race): with race Kidney Function — Serum creatinine Measure/Method of Assessment: Measured using a chemical autoanalyzer with standardized assays

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Health status/ Comorbidities: Included: Low skeletal muscle mass; generally healthy according to responses to a standard health screening questionnaire Excluded: malignancy in the past 5 years, diabetes, advanced renal disease, neuromuscular disease, total walking incapacity Medication use: Mean (SD) number of medications: 1 (2); Excluded if taking medications that interfere with the nutrition intervention - corticosteroids for systemic use, hormone replacement therapy, insulin, high-dose anti-inflammatories, simvastatin Supplement use: Excluded if consumed LC n-3 PUFA supplementation and were not willing to cease consumption \geq 6 weeks prior to and for the duration of the 24-wk study Pregnant or lactating: NR</p> <p>Intervention 2: Leucine-enriched Protein+ PUFAs N: 38</p>	<p>Mean (SD): 100 (23) g/d; 19.6 (3.3) % of energy Carbohydrate Mean (SD): 229 (60) g/d; 44.6 (6.7) % of energy Fat Mean (SD): 80 (24) g/d; 34.8 (6.3) % of energy</p> <p>Dietary Protein Intake Compliance (%): Median (IQR): 89% (83-94%)</p> <p>Protein type/source: Whey protein and a peptide carrier enriched with free leucine</p> <p>Energy balance status: Eucaloric</p> <p>Intervention 2: Leucine-enriched Protein +PUFAS</p> <p>Intended Protein Amount: 21.2 g in supplemental protein per day; total intake goals NR Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 77 (25) g/d; 17.6 (4.5) % of energy Carbohydrate Mean (SD): 200 (66) g/d; 45.6 (8.4) % of energy Fat Mean (SD): 69 (25) g/d; 35.4 (8.8) % of energy</p> <p>Actual Protein Amount at the end of the study Mean (SD): 92 (25) g/d; 19.9 (4.0) % of energy</p>	<p>pre-, mid-, and post intervention visits</p> <p>Dietary Protein Intake Compliance: Compliance was derived using the self-report supplement logs</p> <p>Intervention 2: Normal Protein</p> <p>How protein was administered: Two supplements daily equaling 21.2 g protein per day (including 6.2 g leucine and 4 g LC n-3 PUFAs); one was consumed before breakfast and one before their second light meal of the day with habitual diet</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p> <p>Comparator: Normal Protein</p> <p>How protein was administered: Isocaloric maltodextrin supplement</p> <p>Protein Assessment Method: Same as above</p>	<p>Kidney Function — Serum cystatin C</p> <p>Measure/Method of Assessment: Measured using a chemical autoanalyzer with standardized assays</p> <p>Kidney Function — Blood urea nitrogen</p> <p>Measure/Method of Assessment: Measured using a chemical autoanalyzer with standardized assays</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>% Female: 55.3% Mean Age (SD): 73 (6) y Race/Ethnicity: 100% White Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.7 (3.2) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 8257 (3906) steps/d Health status/Comorbidities: Included: Low skeletal muscle mass; generally healthy according to responses to a standard health screening questionnaire Excluded: malignancy in the past 5 years, diabetes, advanced renal disease, neuromuscular disease, total walking incapacity Medication use: Mean (SD) number of medications: 2 (2); Excluded if taking medications that interfere with the nutrition intervention - corticosteroids for systemic use, hormone replacement therapy, insulin, high-dose anti-inflammatories, simvastatin</p>	<p>Carbohydrate Mean (SD): 200 (57) g/d; 43.5 (8.0) % of energy Fat Mean (SD): 76 (28) g/d; 36.2 (7.8) % of energy</p> <p>Dietary Protein Intake Compliance (%): Median (IQR): 92% (87-97%)</p> <p>Protein type/source: Animal; whey protein and a peptide carrier enriched with free leucine</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Normal Protein</p> <p>Intended Protein Amount: NR Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 79 (34) g/d; 16.7 (5.3) % of energy Carbohydrate Mean (SD): 214 (62) g/d; 45.6 (7.5) % of energy Fat Mean (SD): 80 (34) g/d; 37.4 (9.3) % of energy</p> <p>Actual Protein Amount at the end of the study Mean (SD): 83 (23) g/d; 15.2 (3.2) % of energy Carbohydrate Mean (SD): 268 (68) g/d; 49.8 (5.6) % of energy</p>	<p>Dietary Protein Intake Compliance: Same as above</p>	

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Supplement use: Excluded if consumed LC n-3 PUFA supplementation and were not willing to cease consumption \geq 6 weeks prior to and for the duration of the 24-wk study Pregnant or lactating: NR</p> <p>Comparator: Normal Protein N: 31 % Female: 45.2% Mean Age (SD): 73 (7) y Race/Ethnicity: 100% White Menopausal status: NR Obesity status: NR Mean BMI (SD): 25.4 (2.8) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 8192 (5142) steps/day Health status/Comorbidities: Included: Low skeletal muscle mass; generally healthy according to responses to a standard health screening questionnaire Excluded: malignancy in the past 5 years, diabetes, advanced renal disease, neuromuscular disease, total walking incapacity</p>	<p>Fat Mean (SD): 85 (30) g/d; 34.8 (5.4) % of energy</p> <p>Dietary Protein Intake Compliance (%): Median (IQR): 93% (87-95%)</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 24 weeks</p>		

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Medication use: Mean (SD) number of medications: 2 (3); Excluded if taking medications that interfere with the nutrition intervention - corticosteroids for systemic use, hormone replacement therapy, insulin, high-dose anti-inflammatories, simvastatin</p> <p>Supplement use: Excluded if consumed LC n-3 PUFA supplementation and were not willing to cease consumption \geq 6 weeks prior to and for the duration of the 24-wk study</p> <p>Pregnant or lactating: NR</p>			
<p>PMID: 34098214 Peng 2021^{*37} Location/Country: Taiwan/China HDI: High Setting: Community dwelling Urban/ Rural: NR Study design: RCT (parallel) Funding source: Academic, industry Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 52</p> <p>Intervention: High Protein N: 27 % Female: 48.1% Mean Age (SD): 53.4 (8.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 25.1 (3.9) kg/m² Income level: NR Mean education level (SD): 14.1 (2.9) y</p>	<p>Intervention: High Protein</p> <p>Intended Protein Amount: 25% of energy Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p>	<p>Intervention: High Protein</p> <p>How protein was administered: Received 10 frozen meals per week for 12 weeks containing 25% energy in protein.</p> <p>Protein Assessment Method: NR</p> <p>Dietary Protein Intake Compliance: Insufficient compliance to the study protocol (e.g low meal complete rate and</p>	<p>Kidney Function — eGFR</p> <p>Measure/Method of Assessment: Serum creatinine measured using a chemical autoanalyzer with standardized assays. Measurement methods for eGFR were not reported</p> <p>eGFR cut off (with or without race): NR</p> <p>Kidney Function — Serum creatinine</p> <p>Measured using a chemical autoanalyzer with standardized assays.</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Mean physical activity level (SD): 1567.3 (1244.9) kcal/wk</p> <p>Health status/ Comorbidities: Excluded: (1) history of fracture or severe arthritis in recent 6 months, (2) known history of chronic kidney disease stage III and over, i.e. estimated glomerular filtered rate (eGFR) < 60 ml/min/1.73 m², (3) contraindicated for magnetic resonance imaging, (4) using anabolic hormones in the past 3 months, (5) were disability or limited functional ability, (6) having advanced, active or uncontrolled diseases, and (6) dementia, cognitive impairment or other sensory impairment that limited communication and understanding of the study</p> <p>Medication use: Excluded those using anabolic hormones</p> <p>Supplement use: NR</p> <p>Pregnant or lactating: NR</p> <p>Comparator: Normal Protein</p> <p>N: 25</p> <p>% Female: 44%</p> <p>Mean Age (SD): 54 (8.6) y</p>	<p>Dietary Protein Intake Compliance (%): 91.2%</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Normal Protein</p> <p>Intended Protein Amount: 15% of energy</p> <p>Carbohydrate: NR</p> <p>Fat: NR</p> <p>Baseline Protein Amount Mean (SD): NR</p> <p>Carbohydrate Mean (SD): NR</p> <p>Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study Mean (SD): NR</p> <p>Carbohydrate Mean (SD): NR</p> <p>Fat Mean (SD): NR</p> <p>Dietary Protein Intake Compliance (%): 79.5%</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 12 weeks</p>	<p>vigorous changes of lifestyle)</p> <p>Comparator: Normal Protein</p> <p>How protein was administered: Received 10 frozen meals per week for 12 weeks containing 15% energy in protein.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	<p>Kidney Function — Blood urea nitrogen</p> <p>Measure/Method of Assessment: Measured using a chemical autoanalyzer with standardized assays</p> <p>Serum creatinine, eGFR, blood urea nitrogen.</p>

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Race/Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 25.6 (3.8) kg/m² Income level: NR Mean education level (SD): 15.5 (2.7) y Mean physical activity level (SD): 1954.0 (1646.4) kcal/wk Health status/ Comorbidities: Excluded: (1) history of fracture or severe arthritis in recent 6 months, (2) known history of chronic kidney disease stage III and over, i.e. estimated glomerular filtered rate (eGFR) < 60 ml/min/1.73 m², (3) contraindicated for magnetic resonance imaging, (4) using anabolic hormones in the past 3 months, (5) were disability or limited functional ability, (6) having advanced, active or uncontrolled diseases, and (6) dementia, cognitive impairment or other sensory impairment that limited communication and understanding of the study Medication use: Excluded those using anabolic hormones Supplement use: NR</p>			

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	Pregnant or lactating: NR			
PMID: 22406907 Wycherley 2012 ^{*38} Location/Country: Australia HDI: Very high Setting: Community dwelling Urban/Rural: NR Study design: RCT (parallel) Funding source: Industry Risk of bias score: Moderate	Study of: Adults Total sample N: 68 Intervention: High Protein N: 33 % Female: 0% Mean Age (SD): 51.3 (9.4) y Race/Ethnicity: NR Menopausal status: NA Obesity status: 100% overweight or obese Mean BMI (SD): 33.0 (3.9) kg/m ² (total study population mean) Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Excluded: diabetes, uncontrolled hypertension; history of GI, renal, coronary, metabolic, or hepatic disease or malignancy Medication use: Excluded those taking hypoglycemic medication or drugs which affect insulin sensitivity Supplement use: NR Pregnant or lactating: NA Comparator: Low Protein N: 35 % Female: 0% Mean Age (SD): 50.2 (9.3) y	Intervention: High Protein Intended Protein Amount: 35% of energy; 142 g/d; ~1.30 g/kg/d Carbohydrate: 40% of energy; 135 g/d Fat: 25% of energy (total 53 g/d, saturated 14 g/d) Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Actual Protein Amount at the end of the study: Mean (SD): 0-12 weeks: 131.1 (15.4) g/d; 32.5 (3.3) % of energy 12-52 weeks: 132 (13.9) g/d; 30.7 (3.1) % of energy Carbohydrate Mean (SD): 0-12 weeks: 154.4 (31.8) g/d; 37.4 (3.8) % of energy 12-52 weeks: 157.9 (28.1) g/d; 35.9 (3.4) % of energy Fat Mean (SD): 0-12 weeks: 50.6 (6.5) g/d; 27.3 (3.0) % of energy 12-52 weeks: 60.0 (12.6) g/d; 29.8 (3.6) % of energy Dietary Protein Intake Compliance (%): NR – good compliance rate stated Protein type/source: Mixed	Intervention: High Protein How protein was administered: Participants met with dietitian and received detailed dietary prescription, meal planning advice, and recipe information every 2 weeks for the first 12 weeks. They were supplied with a 2-week provision of diet-specific key foods (60% of energy intake) for the first 12 weeks. Participants met with dietician monthly and received detailed dietary prescription, meal planning advice, and recipe information for remainder of study duration. Protein Assessment Method: Participants kept a daily semi-quantitative food record. Dietary intake was assessed using a computerized database (Foodworks Professional Edition, version 4, 1998; Xyris Software, Highgate Hill, Australia) based on the analysis of 3 non-consecutive days (1	Kidney Function — Creatinine Clearance Measure/Method of Assessment: Creatinine clearance was calculated as (urine creatinine (mmol-1) x urine volume (ml))/(plasma creatinine (mmol-1) x minutes) and corrected for body surface.

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Race/Ethnicity: NR Menopausal status: NA Obesity status: 100% overweight or obese Mean BMI (SD): 33.0 (3.9) kg/m² (total study population mean) Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Excluded: diabetes, uncontrolled hypertension; history of GI, renal, coronary, metabolic, or hepatic disease or malignancy Medication use: Excluded those taking hypoglycemic medication or drugs which affect insulin sensitivity Supplement use: NR Pregnant or lactating: NA</p>	<p>Energy balance status: Hypocaloric</p> <p>Comparator: Low Protein</p> <p>Intended Protein Amount: 17% of energy; 88 g/d; ~0.85 g/kg/d Carbohydrate: 58% of energy; 198 g/d Fat: 25% of energy (total 51 g/d, saturated 14 g/d)</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study Mean (SD): 0-12 weeks: 82.7 (6.7) g/d; 20.5 (1.4) % of energy 12-52 weeks: 83.3 (10.3) g/d; 20.4 (1.0) % of energy Carbohydrate Mean (SD): 0-12 weeks: 208.4 (16.3) g/d; 51.0 (3.6) % of energy 12-52 weeks: 195.2 (23.4) g/d; 47.3 (3.9) % of energy Fat Mean (SD): 0-12 weeks: 46.7 (7.5) g/d; 25.0 (3.3) % of energy 12-52 weeks: 52.2 (8.7) g/d; 27.7 (3.2) % of energy</p> <p>Dietary Protein Intake Compliance (%): NR – good compliance rate stated</p> <p>Protein type/source: Mixed</p>	<p>weekend day and 2 weekdays) of each 2-week period. The intake was calculated as an average of the 2-week diet record data blocks for 0-12 weeks and 12-52 weeks.</p> <p>Dietary Protein Intake Compliance: Food checklist</p> <p>Comparator: Low Protein</p> <p>How protein was administered: Participants met with dietitian and received detailed dietary prescription, meal planning advice, and recipe information every 2 weeks for the first 12 weeks. They were supplied with a 2-week provision of diet-specific key foods (60% of energy intake) for the first 12 weeks. Participants met with dietician monthly and received detailed dietary prescription, meal planning advice, and recipe information for remainder of study duration.</p> <p>Protein Assessment Method: Same as above</p>	

Study	Participants	Interventions/Exposure and Comparator (Content, administrator, and duration)	Intervention (s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
		Energy balance status: Hypocaloric Study duration: 52 weeks	Dietary Protein Intake Compliance: Same as above	

Abbreviations: AER = albumin excretion rate; BMI = Body Mass Index; CKD = chronic kidney disease; d = days; DASH = Dietary Approaches to Stop Hypertension; e.g. = exempli gratia; eGFR = estimated glomerular filtration rate; g = grams; HDI = human development index; IU = international units; kg = kilogram; kg/m² = kilogram per meters squared; kcal = kilocalories; LC n-3 PUFA = n-3 long chain polyunsaturated fatty acids; mg = milligrams; NA = not applicable; NR = not reported; PMID = PubMed Identification Number; PUFA = polyunsaturated fatty acids; RCT = randomized controlled trial; RoB = Risk of Bias; SD = Standard deviation; SE = standard error; SEM = standard error of the mean; USA = United States of America; wk = week; y = year

Note: * Studies overlap KQs

Table C4. Evidence table for Kidney Disease Non-Randomized Controlled Trials

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
PMID: 33203389 Alviridzadeh 2020 ³⁹ Location/Country: Iran HDI: High Setting: Community dwelling Urban/ Rural: Urban Study Design: Prospective cohort study Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 1630 Tertile 1: Lower protein intake N: 544 % Female: 55.7% Mean Age (SD): 43.3 (11.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.4 (4.5) kg/m ² Income level: NR Education level: NR Physical activity level: 68.2% low physical activity Health status/ Comorbidities: No history of myocardial infarction or stroke or CKD Medication use: NR Supplement use: NR Pregnant or lactating: NR	Tertile 1: Lower protein intake Baseline Protein Amount Mean (SD): 50.36 (9.83) g Carbohydrate Mean (SD): 58.1 (7.6) % of energy Fat Mean (SD): 31. (7.7) % energy Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Tertile 2: Moderate protein intake Baseline Protein Amount Mean (SD): 74.23 (6.43) g Carbohydrate Mean (SD): 57.6 (6.8) % of energy Fat Mean (SD): 31.4 (6.9) % of energy	Protein Assessment Method: The dietary intakes were assessed using a valid and reliable semi-quantitative FFQ by trained dietitians during face-to-face interviews. The United States Department of Agriculture food composition table was applied. Protein intake was only assessed at baseline	Kidney Function — Incident CKD Measure/Method of Assessment: CKD derived from MDRD equation with serum creatinine, using eGFR < 60 ml/min/1.73 m ² eGFR CKD cut off point: eGFR < 60 ml/min/1.73m ² eGFR measurement (with or without race): with race

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Tertile 2: Moderate protein intake N: 542 % Female: 52.8% Mean Age (SD): 42.8 (10.9) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.6 (4.7) kg/m² Income level NR Education level: NR Physical activity level: 65.2% low physical activity Health status/ Comorbidities: no history of myocardial infarction or stroke or CKD Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 3: Higher protein intake N: 544 % Female: 43% Mean Age (SD): 42.4 (11.4) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.6 (4.7) kg/m² Income level NR Education level: NR Physical activity level: 67.1% low physical activity Health status/ Comorbidities: no history of myocardial infarction or stroke or CKD Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3: Higher protein intake</p> <p>Baseline Protein Amount Mean (SD): 114.44 (29.42) g Carbohydrate Mean (SD): 57.5 (7.3) % of energy Fat Mean (SD): 30.5 (6.5) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein source/type: Mixed</p> <p>Energy balance: Eucaloric</p> <p>Study duration: 6 years</p>		
PMID: 29439930 Cirillo	Study of: Adults Total sample N: 4307	Arm 1: Low urine urea nitrogen (lowest quintile)	Protein Assessment Method: Overnight urinary	Kidney Function — eGFR

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
<p>2018⁴⁰ Location/Country: Italy HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study Design: Prospective cohort study Funding source: Government, pharmaceutical Risk of bias score: High</p>	<p>Arm 1: Low urine urea nitrogen (lowest quintile) N: 861 % Female: 54.7% Mean Age (SD): 52 (20) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 12.3% Obese Mean BMI (SD): 25.5 (4.2) kg/m² Income level: NR Education level: NR Median physical activity level (95% CI): 0.10 (0.19-0.25) h/d Health status/ Comorbidities: Hypertension: 37.6% Hypercholesterolemia: 29.3% Diabetes: 4.6% Previous cardiovascular disease: 6.4% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Arm 2: Non-low urine urea nitrogen (quintile 2-5) N: 3446 % Female: 54.8% Mean Age (SD): 49 (17) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 22.1% Obese Mean BMI (SD): 27.0 (4.4) kg/m² Income level NR Education level: NR Median physical activity level (95% CI): 0.10 (0.28-0.32) h/d Health status/ Comorbidities: UUN quintile 2:</p>	<p>Baseline Protein Amount Mean (SD): 34.0 g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 2: Non-low urine urea nitrogen (quintile 2-5)</p> <p>Baseline Protein Amount Mean (SD): UUN quintile 2: 52.7 g/d UUN quintile 3: 65.0 g/d UUN quintile 4: 78.6 g/d UUN quintile 5: 117.0 g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance: Eucaloric</p> <p>Study duration: 15.9 y</p>	<p>sodium and potassium were used as indices of their dietary intake. Protein intake was only assessed at baseline.</p>	<p>Measure/Method of Assessment: eGFR was calculated by the Chronic Kidney Disease Epidemiology Collaboration equation with serum creatinine.</p> <p>eGFR measurement (with or without race): with race</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Hypertension: 34.1% Hypercholesterolemia: 31.3% Diabetes: 4.2% Previous cardiovascular disease: 5.5% UUN quintile 3: Hypertension: 31.9% Hypercholesterolemia: 29.9% Diabetes: 3.4% Previous cardiovascular disease: 5.4% UUN quintile 4: Hypertension: 33.7% Hypercholesterolemia: 29.2% Diabetes: 5.9% Previous cardiovascular disease: 4.7% UUN quintile 5: Hypertension: 36.1% Hypercholesterolemia: 32.7% Diabetes: 8.0% Previous cardiovascular disease: 3.7% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>			
<p>PMID: 30579675 Farhadnejad 2019⁴¹ Location/Country: Iran HDI: High Setting: Community dwelling Urban/ Rural: Urban Study Design: Prospective cohort study Funding Source: Academic Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 1797</p> <p>Tertile 1: Lower Low-Carbohydrate High-Protein Diet Score N: 691 % Female: 41.4% Mean Age (SD): 39.0 (12.5) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.9 (4.8) kg/m² Income level: NR Education level: NR</p>	<p>Tertile 1: Lower Low-Carbohydrate High-Protein Diet Score</p> <p>Baseline Protein Amount: 3 (1-4) score Carbohydrate: NR Fat: NR</p> <p>Protein Amount at the end of the study Mean (SD): 12.9 (1.7) % of energy Carbohydrate Mean (SD): 64.1 (4.0) % of energy Fat Mean (SD): 25.6 (4.2) % of energy</p>	<p>Protein Assessment Method: Food intakes of participants over the previous year were assessed using a valid and reliable semiquantitative food-frequency questionnaire, by expert interviewers in the third survey of the TLGS as baseline phase of the present study. This food-frequency questionnaire consisted of 168 food items commonly consumed by Iranians, with standard</p>	<p>Kidney Function — Incident CKD</p> <p>Measure/Method of Assessment: Measured using eGFR < 60 ml/min/1.73 m² from MDRD equation with serum creatinine.</p> <p>eGFR CKD cut off point: eGFR<60 mL/minute/1.73 m²</p> <p>eGFR measurement (with or without race): with race</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Median physical activity level (IQR): 46.1 (31.7-56.4) MET-h/week Health status/ Comorbidities: Diabetes: 11.5% Hypertension: 19.0% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 2: Moderate Low-Carbohydrate High-Protein Diet Score N: 685 % Female: 56% Mean Age (SD): 37.1 (12.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.7 (4.7) kg/m² Income level NR Education level: NR Median physical activity level (IQR): 49.1 (37.3-59.7) MET-h/week Health status/ Comorbidities: Diabetes: 11.0% Hypertension: 15.9% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 3: Higher Low-Carbohydrate High-Protein Diet Score N: 421 % Female: 63.4% Mean Age (SD): 36.6 (12.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR</p>	<p>Tertile 2: Moderate Low-Carbohydrate High-Protein Diet Score</p> <p>Baseline Protein Amount: 7 (7-8) score Carbohydrate: NR Fat: NR</p> <p>Protein Amount at the end of the study Mean (SD): 13.0 (2.2) % of energy Carbohydrate Mean (SD): 54.5 (5.2) % of energy Fat Mean (SD): 35.0 (6.5) % of energy</p> <p>Tertile 3: Higher Low-Carbohydrate High-Protein Diet Score</p> <p>Baseline Protein Amount: 10 (9-11) Carbohydrate: NR Fat: NR</p> <p>Protein Amount at the end of the study Mean (SD): 15.8 (2.1) % of energy Carbohydrate Mean (SD): 51.0 (4.1) % of energy Fat Mean (SD): 35.5 (4.3) % of energy</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 6.1 years</p>	<p>serving size. Their consumption frequency for each food item during the previous year on a daily, weekly, or monthly basis. The portion sizes of consumed foods were reported in household measures and then converted to grams. The United States Department of Agriculture (USDA) Food Composition Table (FCT) was used. For protein, those with the highest and lowest protein intakes received 4 and 0 points, respectively. Protein intake was only assessed at baseline.</p>	

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	Mean BMI (SD): 26.6 (4.8) kg/m ² Income level NR Education level: NR Median physical activity level (IQR): 49.2 (49.1-67.4) MET-h/week Health status/ Comorbidities: Diabetes: 12.6% Hypertension: 18.3% Medication use: NR Supplement use: NR Pregnant or lactating: NR			
PMID: 19443643 Halbesma 2009 ⁴² Location/Country: Netherlands HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study Design: Prospective cohort study Funding Source: Nonprofit Risk of bias score: Very high	Study of: Adults Total sample N: 8461 Quintile 1: 0.26-0.99 g of protein/kg/d (combined male and female) N: 1692 % Female: NR Mean Age (SD): 49.0 (13.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.6 (3.8) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Cardiovascular disease history: 13.8% Medication use: NR Supplement use: NR Pregnant or lactating: NR Quintile 2: 0.96 to 1.13 g of protein/kg/d (combined male and female) N: 1692	Quintile 1: 0.26-0.99 g of protein/kg/d (combined male and female) Baseline Protein Amount Mean (SD): 0.26-0.99 g of protein/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Quintile 2: 0.96 to 1.13 g of protein/kg/d (combined male and female) Baseline Protein Amount: Mean (SD): 0.96 to 1.13 g of protein/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR	Protein Assessment Method: Protein intake was calculated by the method of Maroni and colleagues, in each of the two 24-h urine collections obtained during the first screening round. Protein intake was only assessed at baseline.	Kidney Function — eGFR Measure/Method of Assessment: Derived using the MDRD study equation with serum creatinine. eGFR measurement (with or without race): with race

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>% Female: NR Mean Age (SD): 50.0 (13.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 25.3 (3.6) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Cardiovascular disease history: 12.1% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 3: 1.10 to 1.26 g of protein/kg/d (combined male and female) N: 1693 % Female: NR Mean Age (SD): 49.7 (12.9) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 25.7 (3.8) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Cardiovascular disease history: 11.9% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 4: 1.22 to 1.42 g of protein/kg/d (combined male and female) N: 1692 % Female: NR</p>	<p>Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 3: 1.10 to 1.26 g of protein/kg/d (combined male and female)</p> <p>Baseline Protein Amount: mean: 1.10 to 1.26 g of protein/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 4: 1.22 to 1.42 g of protein/kg/d (combined male and female)</p> <p>Baseline Protein Amount 1.22 to 1.42 g of protein/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 5: 1.38 to 3.27 g of protein/kg/d (combined male and female)</p> <p>Baseline Protein Amount: 1.38 to 3.27 g of protein/kg/d (combined male and female) Carbohydrate Mean (SD): NR</p>		

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Mean Age (SD): 50.0 (12.4) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.6 (4.0) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Cardiovascular disease history: 9.7% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 5: 1.38 to 3.27 g of protein/kg/d (combined male and female) N: 1692 % Female: NR Mean Age (SD): 50.2 (11.4) y Race /Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI at baseline: 28.2 (4.2) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Cardiovascular disease history: 10.1% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 6.4 y</p>		
<p>PMID: 28065493 Haring 2017⁴³ Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: Other</p>	<p>Study of: Adults Total sample N: 11952</p> <p>Quintile 1: Protein intake 41.1 (7.3) g/d N: 2391 % Female: 64.2%</p>	<p>Quintile 1: Protein intake 41.1 (7.3) g/d</p> <p>Baseline Protein Amount Mean (SD): 41.1 (7.3) g/d Carbohydrate Mean (SD): 135.2 (54.3) g/d</p>	<p>Protein Assessment Method: Interviewer-administered, 66-item food frequency questionnaire. The FFQ was administered to all subjects at visit 1 (baseline, 1987–1989) and visit 3</p>	<p>Kidney Function — Incident CKD</p> <p>Measure/Method of Assessment: eGFR was calculated using the 2009 Chronic Kidney Disease</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
<p>Study Design: Prospective cohort study Funding Source: Government Risk of bias score: High</p>	<p>Mean Age (SD): 53.8 (5.8) y Race/ Ethnicity: Black: 23.3% White: 76.7% Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.6 (5.1) kg/m² Income level: NR Education level: Less than high school: 24.8% High school or equivalent: 45.3% College or above: 29.9% Mean physical activity level (SD): Baecke's physical activity index: 2.4 (0.8) Health status/ Comorbidities: Hypertension: 30.7% Medication use: Antihypertensive medication: 22.6%, Lipid lowering medication: 2.1% Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 2: Protein intake 57.2 (3.6) g/d N: 2390 % Female: 56.9% Mean Age (SD): 53.8 (5.7) y Race/ Ethnicity: Black: 22.6% White: 77.4% Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.8 (4.9) kg/m² Income level: NR Education level: Less than high school: 20.3%</p>	<p>Fat Mean (SD): 35.8 (11.3) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 2: Protein intake 57.2 (3.6) g/d</p> <p>Baseline Protein Amount Mean (SD): 57.2 (3.6) g/d Carbohydrate Mean (SD): 155.7 (55.1) g/d Fat Mean (SD): 47.7 (13.0) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 3: Protein intake 69.0 (3.3) g/d</p> <p>Baseline Protein Amount Mean (SD): 69.0 (3.3) g/d Carbohydrate Mean (SD): 178.4 (59.6) g/d Fat Mean (SD): 56.6 (14.7) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 4: Protein intake 82.3 (4.5) g/d</p>	<p>(1993–1995). Protein intake was assessed at baseline and visit 3.</p>	<p>Epidemiology (CKD-EPI) equation using serum creatinine.</p> <p>eGFR CKD cut off point: eGFR<60 mL/minute/1.73 m²</p> <p>eGFR measurement (with or without race): with race</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>High school or equivalent: 42.9% College or above: 36.8% Mean physical activity level (SD): Baecke's physical activity index: 2.5 (0.8) Health status/ Comorbidities: Hypertension: 30.8% Medication use: Antihypertensive medication: 22.2% Lipid lowering medication 2.3% Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 3: Protein intake 69.0 (3.3) g/d N: 2391 % Female: 57.8% Mean Age (SD): 53.8 (5.7) y Race/ Ethnicity: Black: 22.7% White: 77.3% Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.1 (5.0) kg/m² Income level: NR Education level: Less than high school: 18.9% High school or equivalent: 40.2% College or above: 41.0% Mean physical activity level (SD): Baecke's physical activity index: 2.5 (0.8) Health status/ Comorbidities: Hypertension: 32.6% Medication use: Antihypertensive medication: 24.5%</p>	<p>Baseline Protein Amount Mean (SD): 82.3 (4.5) g/d Carbohydrate Mean (SD): 199.9 (62.2) g/d Fat Mean (SD): 66.2 (16.6) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 5: Protein intake 109.5 (18.3) g/d</p> <p>Baseline Protein Amount Mean (SD): 109.5 (18.3) g/d Carbohydrate Mean (SD): 244.6 (76.0) g/d Fat Mean (SD): 87.7 (25.2) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 25 years</p>		

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Lipid lowering medication: 2.4% Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 4: Protein intake 82.3 (4.5) g/d N: 2390 % Female: 55.4% Mean Age (SD): 53.8 (5.7) y Race/ Ethnicity: Black: 22.1% White: 77.9% Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.2 (5.0) kg/m² Income level: NR Education level: Less than high school: 18.9% High school or equivalent: 40.3% College or above: 40.8% Mean physical activity level (SD): Baecke's physical activity index: 2.5 (0.8) Health status/ Comorbidities: Hypertension: 31.0% Medication use: Antihypertensive medication: 23.1% Lipid lowering medication 2.0% Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 5: Protein intake 109.5 (18.3) g/d N: 2390 % Female: 47.0% Mean Age (SD): 53.7 (5.6) y Race/ Ethnicity: Black: 23.5%</p>			

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	White: 76.5% Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.6 (5.1) kg/m ² Income level: NR Education level: Less than high school: 19.1% High school or equivalent: 40.1% College degree or above: 40.8% Mean physical activity level (SD): Baecke's physical activity index: 2.5 (0.8) Health status/ Comorbidities: Hypertension: 28.7% Medication use: Antihypertensive medication: 20.3% Lipid lowering medication 2.1% Supplement use: NR Pregnant or lactating: NR			
PMID: 27935525 Herber-Gast 2016⁴⁴ Location/Country: Netherlands HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study Design: Prospective cohort study Funding Source: Nonprofit Risk of bias score: High	Study of: Adults Total sample N: 3763 Tertile 1: Lower energy-adjusted total dairy intake N: 1213 % Female: 42.1% Mean Age (SD): 45 (9) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 10% Obese Mean BMI (SD): 25.5 (3.7) kg/m ² Income level: NR Education level: Low education: 46.0% Physical activity level: Inactive: 4.6%	Tertile 1: Lower energy-adjusted total dairy intake Baseline Protein Amount Mean (SD): 76.7 (9.6) g/d Carbohydrate: NR Fat Mean (SD): Monounsaturated fat: 33.8 (5.4) g/d Polyunsaturated fat: 17.6 (4.0) g/d Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR	Protein Assessment Method: Diet was assessed at rounds 2–4 with the use of a self-administered semiquantitative food-frequency questionnaire (FFQ) that was developed for the European Prospective Investigation into Cancer and Nutrition study. Participants reported their usual intakes of 178 food and beverage items over the previous 12 mo. Colored photographs were used to facilitate the estimation of portion sizes, and the seasonal variation in food consumption was taken into	Kidney function — eGFR Measure/Method of Assessment: Cystatin C was based on a particle-enhanced turbidimetric immunoassay; eGFR was estimated with the use of the Chronic Kidney Disease Epidemiology Collaboration equation with cystatin C. eGFR measurement (with or without race): with race

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Moderately inactive: 20.4% Moderately active: 27.1% Active: 47.9%</p> <p>Health status/ Comorbidities: Hypertension: 30.1% Hypercholesterolemia: 23.1% Diabetes: 1.2% Obesity: 10.0%</p> <p>Medication use: NR Supplement use: NR Pregnant or lactating: pregnant women were censored at the round in which they reported to be pregnant</p> <p>Tertile 2: Moderate energy-adjusted total dairy intake N: 1297 % Female: 48.8% Mean Age (SD): 45 (10) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 7.2% Obese Mean BMI (SD): 26.7 (4.7) kg/m² Income level NR Education level: Low education: 39.5% Physical activity level: Inactive: 2.7% Moderately inactive: 17.1% Moderately active: 26.7% Active: 53.5% Health status/ Comorbidities: Hypertension: 28.6% Hypercholesterolemia: 21.2% Diabetes: 1.0% Obesity: 7.2% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Tertile 2: Moderate energy-adjusted total dairy intake</p> <p>Baseline Protein Amount Mean (SD): 81.4 (8.7) g/d Carbohydrate: NR Fat Mean (SD): Monounsaturated fat: 32.7 (4.7) g/d Polyunsaturated fat: 16.9 (3.7) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3: Higher energy-adjusted total dairy intake</p> <p>Baseline Protein Amount Mean (SD): 88.8 (9.6) g/d Carbohydrate: NR Fat Mean (SD): Monounsaturated fat: 30.8 (4.7) g/d Polyunsaturated fat: 15.4 (3.4) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 20 y</p>	<p>account. The consumption of food items (in grams per day) and nutrient intakes were calculated with the use of an extended version of the Dutch Food Composition database of 1996. Protein intake was assessed at study visits 2 (baseline for this analysis), 3, and 4.</p>	

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Tertile 3: Higher energy-adjusted total dairy intake N: 1253 % Female: 64.3% Mean Age (SD): 45 (10) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 9.1% Obese Mean BMI (SD): 25.3 (3.6) kg/m² Income level NR Education level: Low education: 41.2% Physical activity level: Inactive: 2.7% Moderately inactive: 15.9% Moderately active: 26.5% Active: 54.9% Health status/ Comorbidities: Hypertension: 26.6% Hypercholesterolemia: 21.4% Diabetes: 1.5% Obesity: 9.1% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>			
<p>PMID: 30115136 Hruby 2018⁴⁵ Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study Design: Prospective cohort study Funding Source: Nonprofit, government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 3066</p> <p>Quartile 1: Average 62.7 g of protein/d N: 940 % Female: 40% Mean Age (SE): 55.1 (0.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 23.8% Obese Mean BMI (SE): 26.7 (0.2) kg/m² Income level: NR Education level: NR Mean physical activity level (SE): 35.3 (0.2) MET-h/wk</p>	<p>Quartile 1: Average 62.7 g of protein/d</p> <p>Baseline Protein Amount Median: 62.7 g/d Carbohydrate Mean: 253.9 g/d Fat Mean: 59.8 g/d</p> <p>Protein Amount at the end of the study Median: NR Carbohydrate Mean: NR Fat Mean: NR</p> <p>Quartile 2: Average 73.7 g of protein/d</p>	<p>Protein Assessment Method: The Harvard semi-quantitative, 126-item FFQ. Protein intake (g/d) was adjusted for total energy intake using the residual method. Quartile categories were created of the average of the reported intake at the beginning and end of each exam interval (e.g. mean of intake reported at exams 5 and 6, for change in outcome between exams 5 and 6). Protein was measured in exams five through nine, and each exam takes four years.</p>	<p>Kidney function — eGFR</p> <p>Measure/Method of Assessment: Derived using the CKD Epidemiology Collaboration Equation with serum creatinine.</p> <p>eGFR measurement (with or without race): without race</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Health status/ Comorbidities: Treatment for hypertension: 17.0% Treatment of CVD: 25.0% Treatment of diabetes: 2.0% History of cancer: 16.0% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 2: Average 73.7 g of protein/d N: 742 % Female: 55% Mean Age (SE): 54.4 (0.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 23.8% Obese Mean BMI (SE): 27.1 (0.2) kg/m² Income level: NR Education level: NR Mean physical activity level (SE): 34.6 (0.2) MET-h/wk Health status/ Comorbidities: Treatment for hypertension: 17.0% Treatment for CVD: 24.0% Treatment for diabetes: 2.0% History of cancer: 16.0% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 3: Average 82.4 g of protein/d N: 650 % Female: 59% Mean Age (SE): 54.2 (0.4) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 23.8% Obese</p>	<p>Baseline Protein Amount Median: 73.7 g/d Carbohydrate Mean: 242.8 g/d Fat Mean: 63.1 g/d</p> <p>Protein Amount at the end of the study Median: NR Carbohydrate: NR Fat: NR</p> <p>Quartile 3: Average 82.4 g of protein/d</p> <p>Baseline Protein Amount Median: 82.4 g/d Carbohydrate Mean: 232.8 g/d Fat Mean: 63.7 g/d</p> <p>Protein Amount at the end of the study Median: NR Carbohydrate: NR Fat: NR</p> <p>Quartile 4: Average 94.5 g of protein/d</p> <p>Baseline Protein Amount Median: 94.5 g/d Carbohydrate Mean: 219.1g/d Fat Mean: 65.0 g/d</p> <p>Protein Amount at the end of the study Median: NR Carbohydrate: NR Fat: NR</p> <p>Protein type/source: Mixed</p>		

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Mean BMI (SE): 27.6 (0.2) kg/m² Income level: NR Education level: NR Mean physical activity level (SE): 34.6 (0.2) MET-h/wk Health status/ Comorbidities: Treatment for hypertension: 17.0% Treatment for CVD: 25.0% Treatment for diabetes: 4.0% History of cancer: 18.0% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 4: Average 94.5 g of protein/d N: 734 % Female: 62% Mean Age (SE): 53.7 (0.4) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 23.8% Obese Mean BMI (SE): 28.2 (0.2) kg/m² Income level: NR Education level: NR Mean physical activity level (SE): 34.7 (0.2) MET-h/wk Health status/ Comorbidities: Treatment for hypertension: 19.0% Treatment for CVD: 27.0% Treatment for diabetes: 5.0% History of cancer: 15.0% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Energy balance status: Eucaloric</p> <p>Study duration: 20 y</p>		
<p>PMID: 31172186 Jhee 2020⁴⁶</p>	<p>Study of: Adults Total sample N: 9226</p>	<p>Quartile 1: Protein intake 0.6 g/kg/d</p> <p>Baseline Protein Amount</p>	<p>Protein Assessment Method: Trained dietitians with a semiquantitative food frequency questionnaire.</p>	<p>Hyperfiltration</p> <p>Measure/Method of Assessment: Hyperfiltration</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
<p>Location/Country: South Korea HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study Design: Prospective cohort study Funding Source: Government Risk of bias score: Very high</p>	<p>Quartile 1: Protein intake 0.6 g/kg/d N: 2305 % Female: 63.5% Mean Age (SD): 54.7 (8.9) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.3 (3.3) kg/m² Income level: Low: 52.2% Intermediate: 37.9% High: 9.9% Education level: Low: 50% Intermediate: 43.4% High: 6.6% Physical activity level: 28.1% Health status/ Comorbidities: Hypertension: 17.4% Diabetes: 5.6% Dyslipidemia: 2.2% MI: 0.9% CHF: 0.2% CAD: 0.9% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 2: Protein intake 0.9 g/kg/d N: 2307 % Female: 52.4% Mean Age (SD): 52.2 (8.9) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.6 (3.1) kg/m² Income level: Low: 33.1%</p>	<p>Mean (SD): 0.6 (0.1) g/kg/day Carbohydrate Mean (SD): 4.3 (1.2) g/kg/day Fat Mean (SD): 0.2 (0.1) g/kg/day</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 2: Protein intake 0.9 g/kg/d</p> <p>Baseline Protein Amount Mean (SD): 0.9 (0.1) g/kg/day Carbohydrate Mean (SD): 5.1 (1.3) g/kg/day Fat Mean (SD): 0.4 (0.1) g/kg/day</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 3: Protein intake 1.1 g/kg/d</p> <p>Baseline Protein Amount Mean (SD): 1.1 (0.2) g/kg/day Carbohydrate Mean (SD): 5.7 (1.5) g/kg/day Fat Mean (SD): 0.5 (0.1) g/kg/day</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p>	<p>Based on the FFQ, the subjects were categorized into four groups according to quartiles of daily amount of protein intake at baseline. Protein intake was only assessed at baseline.</p>	<p>was defined as a logarithm transformed eGFR larger than the 95th percentile in the distribution of residuals from the multivariable linear regression after the adjustment for logarithm-transformed age, sex, history of hypertension and/or diabetes, height and weight</p> <p>eGFR measurement (with or without race): with race</p> <p>Kidney Function — eGFR</p> <p>Measure/Method of Assessment: Derived using the CKD Epidemiology Collaboration Equation with serum creatinine.</p> <p>eGFR measurement (with or without race): with race</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Intermediate: 49.2% High: 17.7% Education level: Low: 34.9% Intermediate: 52.5% High: 12.6% Physical activity level: 38.4% Health status/ Comorbidities: Hypertension: 13.8% Diabetes: 6.5% Dyslipidemia: 2.5% MI: 0.7% CHF: 0.2% CAD: 0.8% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 3: Protein intake 1.1 g/kg/d N: 2307 % Female: 48% Mean Age (SD): 50.8 (8.5) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.6 (3.0) kg/m² Income level: Low: 2.2% Intermediate: 50.6% High: 22.1% Education level: Low: 24.3% Intermediate: 58.2% High: 17.5% Physical activity level: 45.0% Health status/ Comorbidities: Hypertension: 14.0% Diabetes: 6.7% Dyslipidemia: 2.5% MI: 0.7% CHF: 0.1%</p>	<p>Quartile 4: Protein intake 1.7 g/kg/d</p> <p>Baseline Protein Amount Mean (SD): 1.7 (0.6) g/kg/day Carbohydrate Mean (SD): 7.3 (2.8) g/kg/day Fat Mean (SD): 0.9 (0.5) g/kg/day</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 13 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>CAD: 0.6% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 4: Protein intake 1.7 g/kg/d N: 2307 % Female: 62% Mean Age (SD): 50.2 (8.2) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.7 (3.1) kg/m² Income level: Low: 25.1% Intermediate: 49.8% High: 25.2% Education level: Low: 22.2% Intermediate: 58.8% High: 19.0% Physical activity level: 47.5% Health status/ Comorbidities: Hypertension: 12.3% Diabetes: 7.0% Dyslipidemia: 2.4% MI: 0.9% CHF: 0.3% CAD: 0.6% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>			
<p>PMID: 12639078 Knight 2003⁴⁷ Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study Design: Prospective cohort study</p>	<p>Study of: Adults Total sample N: 1624</p> <p>Arm 1: Participants with Normal Renal Function (GFR >80 mL/min per 1.73 m²) N: 1135 % Female: 100% Mean Age (SD): 54.8 (6.6) y</p>	<p>Arm 1: Participants with Normal Renal Function (GFR >80 mL/min per 1.73 m²)</p> <p>Baseline Protein Amount Mean (SD): 76.7 (13.6) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): 29.9 (9.1) g/d</p>	<p>Protein Assessment Method: Reported frequency of consumption of each specified unit of food or beverage by using published data on the nutrient content of the specified portions. Protein were measured twice in 1990 and 1994.</p>	<p>Kidney Function — eGFR</p> <p>Measure/Method of Assessment: Derived using the CKD Epidemiology Collaboration Equation with serum creatinine.</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
Funding Source: Government Risk of bias score: Very high	Race/ Ethnicity: White: 98% African American: 1% Menopausal status: NR Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypercholesterolemia: 50% Diabetes: 5% Hypertension: 36% Medication use: NR Supplement use: NR Pregnant or lactating: NR Arm 2: Participants with Mild Renal Insufficiency (estimated GFR>55 mL/min per 1.73 m ² but<80 mL/min per 1.73 m ²) N: 489 % Female: 100% Mean Age (SD): 56.8 (6.5) y Race/ Ethnicity: White: 98% African American: 1% Menopausal status: NR Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypercholesterolemia: 62% Diabetes: 3% Hypertension: 42% Medication use: NR Supplement use: NR Pregnant or lactating: NR	Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Arm 2: Participants with Mild Renal Insufficiency (estimated GFR>55 mL/min per 1.73 m ² but<80 mL/min per 1.73 m ²) Baseline Protein Amount Mean (SD): 76.2 (13.3) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): 30.0 (8.1) g/day Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 11 y		eGFR measurement (with or without race): with race

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
<p>PMID: 37211392 Kubo 2023⁴⁸ Location/Country: Japan HDI: Very high Setting: Community dwelling Urban/ Rural: Other Study Design: Prospective cohort study Funding Source: Other Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 3277</p> <p>Quartile 1: Protein intake 12% of energy N: 819 % Female: 66.4% Mean Age (SD): 58.8 (7.4) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 23.2 (3.1) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Diabetes mellitus: 4.4% Medication use: Cholesterol-lowering medication: 8.3% Antihypertensive medication: 17.5% Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 2: Protein intake 14.2% of energy N: 819 % Female: 63.9% Mean Age (SD): 59.0 (8.5) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 23.4 (3.1) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Diabetes mellitus: 6.7% Medication use:</p>	<p>Quartile 1: Protein intake 12% of energy</p> <p>Baseline Protein Amount Mean (SD): 12% (1.2) % of energy Carbohydrate Mean (SD): 58.6 (8.0) % of energy Fat Mean (SD): 21.3 (4.8) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 2: Protein intake 14.2% of energy</p> <p>Baseline Protein Amount Mean (SD): 14.2 (0.5) % of energy Carbohydrate Mean (SD): 56.1 (5.7) % of energy Fat Mean (SD): 25.3 (4.1) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 3: Protein intake 15.9% of energy</p> <p>Baseline Protein Amount Mean (SD): 15.9 (0.6) % of energy Carbohydrate Mean (SD): 53.6 (5.0) % of energy</p>	<p>Protein Assessment Method: Brief-type self-administered diet history questionnaire (BDHQ) at the baseline survey between 2002 and 2006. Protein was measured only at baseline visit.</p>	<p>Kidney Function — Incident CKD</p> <p>Measure/Method of Assessment: eGFR was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation with serum creatinine and the Japanese coefficient; Incidence of CKD was defined as appearance of reduced eGFR (<60 mL/min/1.73m²) during follow up.</p> <p>eGFR CKD cut off point: eGFR< 60 ml/min/ 1.73m²</p> <p>eGFR measurement (with or without race): with race</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Cholesterol-lowering medication: 9.3% Antihypertensive medication: 18.8% Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 3: Protein intake 15.9% of energy N: 820 % Female: 65% Mean Age (SD): 58.6 (8.5) year Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 23.4 (3.1) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Diabetes mellitus: 5.2% Medication use: Cholesterol-lowering medication: 10.6% Antihypertensive medication: 17.6% Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 4: Protein intake 18.9% of energy N: 819 % Female: 64.4% Mean Age (SD): 58.9 (8.5) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 23.4 (3.1) kg/m² Income level: NR Education level: NR</p>	<p>Fat Mean (SD): 27.4 (4.1) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 4: Protein intake 18.9% of energy</p> <p>Baseline Protein Amount Mean (SD): 18.9 (2.0) % of energy Carbohydrate Mean (SD): 49.1 (5.4) % of energy Fat Mean (SD): 29.4 (4.3) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 12 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	Physical activity level: NR Health status/ Comorbidities: Diabetes mellitus: 6.2% Medication use: Cholesterol-lowering medication: 9.7% Antihypertensive medication: 17.3% Supplement use: NR Pregnant or lactating: NR			
PMID: 35947164 Kwon 2022 ⁴⁹ Location/Country: Korea HDI: Very high Setting: Community dwelling Urban/ Rural: Other Study Design: Prospective cohort study Funding Source: Government Risk of bias score: High	Study of: Adults Total sample N: 7339 Tertile 1: Protein intake <0.8 g/kg/d N: 2140 % Female: 52.9% Mean Age (SD): 53.1 (8.8) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 56.1% obese Mean BMI (SD): 25.5 (3.2) kg/m ² Income level: NR Education level: NR Physical activity level: <7.5 METs-h/wk: 8.1% 7.5–30 METs-h/wk: 56.6% >30 METs-h/wk: 35.2% Health status/ Comorbidities: Hypertension: 44.8% Diabetes mellitus: 12.7% Medication use: NR Mean supplement use (SD): Calcium intake: 279.7 (119.2) mg/day Phosphorus intake: 670.7 (156.5) mg/day Pregnant or lactating: NR Tertile 2: Protein intake 0.8–1.3 g/kg/d	Tertile 1: Protein intake <0.8 g/kg/d Baseline Protein Amount Mean (SD): 11.9 (2.1) % of energy Carbohydrate Mean (SD): 72.5 (6.2) % of energy Fat Mean (SD): 13.9 (5.1) % of energy Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Tertile 2: Protein intake 0.8–1.3 g/kg/d Baseline Protein Amount Mean (SD): 13.5 (1.9) % of energy Carbohydrate Mean (SD): 67.2 (6.2) % of energy Fat Mean (SD): 18.1 (5.1) % of energy Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR	Protein Assessment Method: The study used a semi-quantitative food frequency questionnaire (FFQ) with 103 items to assess dietary intake through in-person interviews conducted by well-trained dietitians every two years. Protein measurement from only baseline visit were used in this study.	Kidney Function — Incident CKD Measure/Method of Assessment: Incident CKD was defined as eGFR < 60 ml/min/ 1.73m ² and eGFR was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation with serum creatinine. eGFR CKD cut off point: eGFR < 60 ml/min/ 1.73m ² eGFR measurement (with or without race): with race Proteinuria Measure/Method of Assessment: presence of proteinuria determined with a dipstick urine test result of protein level equal to trace or more.

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>N: 3531 % Female: 50.6% Mean Age (SD): 51.4 (8.5) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 41.6% obese Mean BMI (SD): 24.5 (2.9) kg/m² Income level: NR Education level: NR Physical activity level: <7.5 METs-h/wk: 6.9% 7.5–30 METs-h/wk: 64.1% >30 METs-h/wk: 29.1% Health status/ Comorbidities: Hypertension: 34.8% Diabetes mellitus: 12.5% Medication use: NR Mean supplement use (SD): Calcium intake: 463.2 (167.6) mg/day; Phosphorus intake: 1003.1 (192.6) mg/day Pregnant or lactating: NR</p> <p>Tertile 3: Protein intake >1.3 g/kg/d N: 1668 % Female: 57.1% Mean Age (SD): 51.1 (8.6) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 30% obese Mean BMI (SD): 23.6 (3.0) kg/m² Income level: NR Education level: NR Physical activity level: <7.5 METs-h/wk: 7.0% 7.5–30 METs-h/wk: 59.3% >30 METs-h/wk: 33.7% Health status/ Comorbidities: Hypertension: 32.0%</p>	<p>Tertile 3: Protein intake >1.3 g/kg/d</p> <p>Baseline Protein Amount Mean (SD): 14.9 (2.2) % of energy Carbohydrate Mean (SD): 62.5 (7.5) % of energy Fat Mean (SD): 21.8 (6.0) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 16 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	Diabetes mellitus: 10.4% Medication use: NR Mean supplement use (SD): Calcium intake: 748.4 (294.9) mg/day Phosphorus intake: 1508.6 (360.4) mg/day Pregnant or lactating: NR			
PMID: 27416946 Lew 2017⁵⁰ Location/Country: Singapore HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study Design: Prospective cohort study Funding Source: Government Risk of bias score: High	Study of: Adults Total sample N: 60,198 Quartile 1: 12.5 g/d median red meat intake N: 15,143 % Female: 50% Mean Age (SD): 56.5 (7.8) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 23.0 (3.3) kg/m ² Income level: NR Education level: Secondary school or higher: 31% Physical activity level: 39% with weekly moderate activity, vigorous activity or strenuous sports lasting at least 30 minutes. Health status/ Comorbidities: Hypertension: 24% Diabetes: 7% 649 Coronary heart disease: 4%, Stroke: 2% Medication use: NR Supplement use: NR Pregnant or lactating: NR Quartile 2: 24.2 g/d median red meat intake N: 15,199 % Female: 46%	Quartile 1: 12.5 g/d median red meat intake Baseline Protein Amount Mean (SD): 53.1 (10.3) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Quartile 2: 24.2 g/d median red meat intake Baseline Protein Amount Mean (SD): 57.6 (7.9) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Quartile 3: 33.4 g/d median red meat intake Baseline Protein Amount Mean (SD): 60.5 (7.6) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR	Protein Assessment Method: Semiquantitative food frequency questionnaire, the dietary nutrients of the food items were derived from the Singapore Food Composition Database, which was developed together with this cohort study and is a food-nutrient database that lists the levels of 96 nutritive/non-nutritive compounds per 100 g of cooked food and beverages in the Singaporean Chinese diet. Protein was measured at baseline.	Kidney Function — Incident ESRD Measure/Method of Assessment: ESRD was defined using the following criteria: 1) serum creatinine level >880 mmol/L (10 mg/dl), 2) eGFR <15 ml/min per 1.73 m ² , 3) hemodialysis or peritoneal dialysis, or 4) kidney transplant. Criteria 1–3 had to be persistent for 3 months to qualify as ESRD eGFR ESRD cut off point: eGFR<15 ml/min per 1.73 m ² eGFR measurement (with or without race): with race

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Mean Age (SD): 56.9 (8.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 23.1 (3.2) kg/m² Income level: NR Education level: Secondary school or higher: 27% Physical activity level: 33% with weekly moderate activity, vigorous activity or strenuous sports lasting at least 30 minutes. Health status/ Comorbidities: Hypertension: 25% Diabetes: 9% Coronary heart disease: 4%, Stroke: 2% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 3: 33.4 g/d median red meat intake N: 14,909 % Female: 56% Mean Age (SD): 56.5 (8.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 23.2 (3.2) kg/m² Income level: NR Education level: Secondary school or higher: 26% Physical activity level: 30% with weekly moderate activity, vigorous activity or strenuous sports lasting at least 30 minutes.</p>	<p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 4: 48.8 g/d median red meat intake</p> <p>Baseline Protein Amount Mean (SD): 65.3 (9.0) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 5 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Health status/ Comorbidities: Hypertension: 23% Diabetes: 10% Coronary heart disease: 4%, Stroke: 1% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 4: 48.8 g/d median red meat intake N: 14,947 % Female: 55% Mean Age (SD): 55.7 (7.9) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 23.2 (3.3) kg/m² Income level: NR Education level: Secondary school or higher: 30%, Physical activity level: 31% with weekly moderate activity, vigorous activity or strenuous sports lasting at least 30 minutes Health status/ Comorbidities: Hypertension: 22% Diabetes: 9% Coronary heart disease: 4% Stroke: 1% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>			
<p>PMID: 27562875 Malhotra 2016⁵¹ Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: NR</p>	<p>Study of: Adults Total sample N: 4255</p> <p>Arm 1: Incident end-stage renal disease cases N: 1057 % Female: 54.4% Mean Age (SD): 54.5 (9.1) y</p>	<p>Arm 1: Incident end-stage renal disease cases</p> <p>Baseline Protein Amount Mean (SD): 15.7 (3.3) % of energy Carbohydrate Mean (SD): 49.7 (9.1) % of energy</p>	<p>Protein Assessment Method: Dietary intake was assessed using a validated food frequency questionnaire at baseline which showed strong agreement for protein intake estimated from the FFQ and 24 hour dietary</p>	<p>Kidney Function — Incident ESRD</p> <p>Measure/Method of Assessment: Incidence of ESRD derived from the US Renal Data System</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
<p>Study Design: Prospective cohort study Funding Source: Government Risk of bias score: Very high</p>	<p>Race/ Ethnicity: 86.7% Black Menopausal status: NR Obesity status: NR Mean BMI (SD): 31.8 (8.2) kg/m² Income level: <\$15,000 annually: 68.3% Education level: <HS: 36.8% Physical activity level: NR Health status/ Comorbidities: Hypertension: 84.2% Diabetes: 63.7% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Arm 2: Control group N: 3198 % Female: 55.2% Mean Age (SD): 54.6 (8.8) y Race/ Ethnicity: 86.8% Black Menopausal status: NR Obesity status: NR Mean BMI (SD): 30.3 (7.2) kg/m² Income level: <\$15,000 annually: 59.6% Education level: <HS: 34.2% Physical activity level: NR Health status/ Comorbidities: Hypertension: 61.4% Diabetes: 23.0% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Fat Mean (SD): 31.1 (6.4) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate: NR Fat: NR</p> <p>Arm 2: Control group</p> <p>Baseline Protein Amount Mean (SD): 15.1 (3.1) % of energy Carbohydrate Mean (SD): 49.6 (9.1) % of energy Fat Mean (SD): 30.9 (6.8) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate: NR Fat: NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 7 y</p>	<p>recalls. Protein was measured at baseline only.</p>	<p>(USRDS), a national disease registry.</p> <p>eGFR measurement (with or without race): not reported</p>
<p>PMID: 29452887 Malhotra 2018⁵² Location/Country: USA HDI: Very high Setting: Community dwelling</p>	<p>Study of: Adults Total sample N: 3165</p> <p>Quintile 1: 10.4 % of Energy From Protein Intake at Baseline</p>	<p>Quintile 1: 10.4 % of Energy From Protein Intake at Baseline</p> <p>Baseline Protein Amount</p>	<p>Protein Assessment Method: Protein intake was estimated from a validated FFQ administered at visit 1.</p>	<p>Kidney Function — eGFR</p> <p>Measure/Method of Assessment: eGFR was calculated using the Chronic Kidney Disease</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
Urban/ Rural: NR Study Design: Prospective cohort study Funding Source: Government, academic Risk of bias score: Very high	<p>N: 633 % Female: 69% Mean Age (SD): 55 (12) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 30.5 (7.0) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypertension: 54% Diabetes: 11% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 2: 12.8% of Energy From Protein Intake at Baseline</p> <p>N: 633 % Female: 65% Mean Age (SD): 55 (12) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 31.1 (6.9) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypertension: 56% Diabetes: 13% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 3: 14.3% of Energy From Protein Intake at Baseline</p> <p>N: 633</p>	<p>Mean (SD): 10.4 (1.3) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 2: 12.8% of Energy From Protein Intake at Baseline</p> <p>Baseline Protein Amount Mean (SD): 12.8 (0.5) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 3: 14.3% of Energy From Protein Intake at Baseline</p> <p>Baseline Protein Amount Mean (SD): 14.3 (0.4) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p>		<p>Epidemiology Collaboration (CKD-EPI) equation with serum creatinine.</p> <p>eGFR measurement (with or without race): with race</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>% Female: 63% Mean Age (SD): 54 (12) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 32.1 (7.2) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypertension: 57% Diabetes: 18% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 4: 16.0% of Energy From Protein Intake at Baseline N: 633 % Female: 58% Mean Age (SD): 54 (11) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 32.2 (7.2) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypertension: 59% Diabetes: 20% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 5: 19.4% of Energy From Protein Intake at Baseline N: 633 % Female: 66%</p>	<p>Quintile 4: 16.0% of Energy From Protein Intake at Baseline</p> <p>Baseline Protein Amount Mean (SD): 16.0 (0.6) % of energy Carbohydrate: NR Fat: NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 5: 19.4% of Energy From Protein Intake at Baseline</p> <p>Baseline Protein Amount Mean (SD): 19.4 (2.5) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 4 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	Mean Age (SD): 54 (11) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 33.1 (6.8) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypertension: 59% Diabetes: 31% Medication use: NR Supplement use: NR Pregnant or lactating: NR			
PMID: 35142012 Sekiguchi 2022 ⁵³ Location/Country: Japan HDI: Very high Setting: Community dwelling Urban/ Rural: Other Study Design: Prospective cohort study Funding Source: Government, academic Risk of bias score: High	Study of: Adults Total sample N: 1960 Quartile 1: 1.01 g/kg/d Protein intake at baseline N: 290 % Female: 13% Mean Age (SD): 74.8 (5.4) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.3 (2.95) kg/m ² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypertension: 54% Diabetes: 11% Dyslipidemia: 35% Stroke: 6.0% Heart disease: 17% Medication use: NR Supplement use: NR Pregnant or lactating: NR Quartile 2: 1.32 g/kg/d Protein intake at baseline	Quartile 1: 1.01 g/kg/d Protein intake at baseline Baseline Protein Amount Mean (SD): 1.01 (0.16) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Quartile 2: 1.32 g/kg/d Protein intake at baseline Baseline Protein Amount Mean (SD): 1.32 (0.07) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR	Protein Assessment Method: Dietary intakes of protein (g/day) and other nutrients during the previous month were assessed using a brief-type self-administered diet history questionnaire (BDHQ) at the baseline survey.	Kidney Function — eGFR Measure/Method of Assessment: eGFR was derived from an equation of the Japanese Society of Nephrology using serum creatinine: eGFR measurement (with or without race): with race

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>N: 290 % Female: 39% Mean Age (SD): 76.5 (5.8) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 23.1 (2.72) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypertension: 54% Diabetes: 12% Dyslipidemia: 33% Stroke: 5.9% Heart disease: 17% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 3: 1.59 g/kg/d Protein intake at baseline</p> <p>N: 290 % Female: 70% Mean Age (SD): 76.5 (5.8) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 22.4 (2.51) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypertension: 46% Diabetes: 10% Dyslipidemia: 39% Stroke: 4.8% Heart disease: 16% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Quartile 3: 1.59 g/kg/d Protein intake at baseline</p> <p>Baseline Protein Amount Mean (SD): 1.59 (0.08) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 4: 2.07 g/kg/d Protein intake at baseline</p> <p>Baseline Protein Amount Mean (SD): 2.07 (0.30) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance: Eucaloric</p> <p>Study duration: 3 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Quartile 4: 2.07 g/kg/d Protein intake at baseline N: 290 % Female: 91% Mean Age (SD): 77.4 (6.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 20.7 (2.48) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Hypertension: 46% Diabetes: 10% Dyslipidemia: 39% Stroke: 4.8% Heart disease: 16% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>			
<p>PMID: 31430246 Shu 2019⁵⁴ Location/Country: China HDI: High Setting: Community dwelling Urban/ Rural: Urban Study Design: Prospective cohort study Funding Source: Government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 127,220</p> <p>Arm 1: SWHS Subjects without incident kidney stones N: 67,715 % Female: NR Mean Age (SD): 52.4 (9.0) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 5% Obese BMI: <18.5 kg/m²: 3.4% 18.5-24.9 kg/m²: 61.6% 25-29.9 kg/m²: 30% ≥30 kg/m²: 5% Income level: Low: 15.9% Middle: 74.6%</p>	<p>Arm 1: SWHS Subjects without incident kidney stones</p> <p>Baseline Protein Amount Mean (SD): 67.1 (20.6) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 2: SWHS Subjects with incident kidney stones</p> <p>Baseline Protein Amount Mean (SD): 67.5 (20.7) g/d Carbohydrate Mean (SD): NR</p>	<p>Protein Assessment Method: FFQ according to the China Food Composition table at baseline.</p>	<p>Kidney stones</p> <p>Measure/Method of Assessment: Incident kidney stone was ascertained as the first report of a urinary tract stone located in the kidney or the ureter during follow-up visits.</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>High: 9.5% Education level: Less than 12th grade: 57.4% High/Vocational school: 36.1% College or above: 4.5% Physical activity level: Rarely/none: 65.1% Low: 12.8% Median: 11.3% High: 10.9% Health status/ Comorbidities: History of coronary heart disease/stroke: 9.6% History of type 2 diabetes: 4.1% History of hypertension: 23.8% History of cholelithiasis: 10.9% Medication use: NR Supplement use: Calcium supplementation: 19% Vitamin C supplementation: 6.9% Pregnant or lactating: NR</p> <p>Arm 2: SWHS Subjects with incident kidney stones N: 1,451 % Female: NR Mean Age (SD): 51.4 (8.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 5.6% Obese BMI: <18.5 kg/m²: 3.0% 18.5-24.9 kg/m²: 58.6% 25-29.9 kg/m²: 32.8% ≥30 kg/m²: 5.6% Income level: Low: 13.6%</p>	<p>Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 3: SMHS subjects without incident kidney stones</p> <p>Baseline Protein Amount Mean (SD): 78.4 (23.6) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 4: SMHS Subjects with incident kidney stones</p> <p>Baseline Protein Amount Mean (SD): 79.6 (23.3) g/d Carbohydrate: NR Fat: NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 8 y</p>		

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Middle: 75.9% High: 10.5% Education level: Less than 12th grade: 55.0% High/Vocational School: 39.8% College or above: 5.2% Physical activity level: Rarely/none: 67.1% Low: 12.4% Median: 11% High: 9.5% Health status/ Comorbidities: History of coronary heart disease/stroke: 11.6% History of type 2 diabetes: 4.4% History of hypertension: 25.8% History of cholelithiasis: 12.7% Medication use: NR Supplement use: Calcium supplementation: 21.4% Vitamin C supplementation: 7.1% Pregnant or lactating: NR</p> <p>Arm 3: SMHS subjects without incident kidney stones N: 56,852 % Female: NR Mean Age (SD): 55.3 (9.7) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 2.5% Obese BMI: <18.5 kg/m²: 4.3% 18.5-24.9 kg/m²: 62.9% 25-29.9 kg/m²: 30.3% ≥30 kg/m²: 2.5%</p>			

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Income level: Low: 12.6% Middle: 77.8% High: 9.6% Education level: Less than 12th grade: 41.3% High/Vocational School: 47.6% College or above: 11.1% Physical activity level: 64.6% Rarely/none: 64.6% Low: 11.9% Median: 12.4% High: 11.1% Health status/ Comorbidities: History of coronary heart disease/stroke: 9.0% History of type 2 diabetes: 6.2% History of hypertension: 30.3% History of cholelithiasis: 7.4% Medication use: NR Supplement use: Calcium supplementation: 4.7% Vitamin C supplementation: 5.5% Pregnant or lactating: NR</p> <p>Arm 4: SMHS Subjects with incident kidney stones N: 1,202 % Female: NR Mean Age (SD): 54.4 (9.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: 3.4% Obese BMI: <18.5 kg/m²: 2.8% 18.5-24.9 kg/m²: 58.3% 25-29.9 kg/m²: 35.4% ≥30 kg/m²: 3.4%</p>			

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	Income level: Low: 11.5% Middle: 78.2% High: 10.3% Education level: Less than 12th grade: 35.5% High/Vocational School: 52.1% College or above: 12.4% Physical activity level: Rarely/none: 66.1% Low: 12.4%, 12.5% Median: 12.5% High: 9.0% Health status/ Comorbidities: History of coronary heart disease/stroke: 8.0% History of type 2 diabetes: 5.9% History of hypertension: 35.3% History of cholelithiasis: 7.6% Medication use: NR Supplement use: Calcium supplementation: 5.2% Vitamin C supplementation: 6.5% Pregnant or lactating: NR			
PMID: 36532536 Teymoori 2022⁵⁵ Location/Country: Iran HDI: High Setting: Community dwelling Urban/ Rural: Urban Study Design: Prospective cohort study Funding Source: Academic, government Risk of bias score: High	Study of: Adults Total sample N: 6044 Tertile 1: Protein score (8.2 ± 2.8) N: 2561 % Female: 57.7% Mean Age (SD): 36.1 (12.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.4 (4.7) kg/m ² Income level: NR	Tertile 1: Protein score (8.2 ± 2.8) Baseline Protein Amount Mean (SD): 13.1 (1.8) % of energy Carbohydrate Mean (SD): 55.9 (6.7) % of energy Fat Mean (SD): 33.4 (6.5) % of energy Protein Amount at the end of the study Mean (SD): NR	Protein Assessment Method: Dietary data were assessed using a valid and reliable semi-quantitative 168-item food frequency questionnaire. During a face-to-face interview, the frequency of consumption for each food item during the past year on a daily, weekly, or monthly basis was collected by trained and skilled dietitians. Protein was measured at baseline.	Kidney Function — Incident CKD Measure/Method of Assessment: CKD was ascertained using eGFR < 60 ml/min/1.73 m ² and eGFR was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation with serum creatinine.

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Education level: Academic education: 22.6% Mean physical activity level (SD): 72.7(60.8) MET/h/wk Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 2: Protein score (9.6 ± 2.8) N: 1714 % Female: 54.9% Mean Age (SD): 37.8 (12.8) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.0 (4.8) kg/m² Income level: NR Education level: Academic education: 26.1% Mean physical activity level (SD): 74.7 (64.2) MET/h/wk Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 3: Protein score (12.0 ± 3.1) N: 1769 % Female: 48.8% Mean Age (SD): 40.4 (13.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.1 (4.6) kg/m² Income level: NR Education level:</p>	<p>Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 2: Protein score (9.6 ± 2.8)</p> <p>Baseline Protein Amount Mean (SD): 14.8 (3.2) % of energy Carbohydrate Mean (SD): 58.4 (6.7) % of energy Fat Mean (SD): 29.6 (5.7) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3: Protein score (12.0 ± 3.1)</p> <p>Baseline Protein Amount Mean (SD): 16.1 (9.8) % of energy Carbohydrate Mean (SD): 61.5 (9.8) % of energy Fat Mean (SD): 27.7 (21.4) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 19 y</p>		<p>eGFR CKD cut off point: eGFR <60 ml/min/1.73 m²</p> <p>eGFR measurement (with or without race): without race</p>

Study	Participants	Intervention(s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	Academic education: 24.6% Mean physical activity level (SD): 75.4 (64.0) MET/h/wk Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR			

Abbreviations: BMI = Body Mass Index; CAD = coronary artery disease; CI = Confidence Interval; CHF = congestive heart failure; CKD = chronic kidney disease; CVD = cardiovascular disease; d = day; eGFR = estimated glomerular filtration rate; ESRD = end stage renal disease; FFQ = Food frequency questionnaire; g = grams; GFR = glomerular filtration rate; h = hours; HDI = human development index; kg = kilograms; kg/m² = kilogram per meters squared; m² = meters squared; MDRD = Modification of Diet in Renal Disease; METs = metabolic equivalents; mg = milligrams; MI = myocardial infarction; min = minutes; ml = milliliter; mmol/L = millimols per liter; NR = not reported; PMID = PubMed Identification Number; RoB = Risk of Bias; SD = Standard deviation; SE = standard error; SMHS = Shanghai Men’s Health Study; SWHS = Shanghai Women’s Health Study; USA = United States of America; UUN = Urine urea nitrogen; wk = week; y = years

Note: *Studies overlap KQs

Table C5. Evidence table for Sarcopenia Randomized Controlled Trials

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
PMID: 26471344 Backx 2016 ⁵⁶ Location/Country: Netherlands HDI: Very high Setting: Community dwelling Urban/Rural: NR Study design: RCT (parallel) Funding Source: Public-private partnership Risk of bias score: Low	Study of: Adults Total sample N: 61 Intervention: High Protein diet N: 31 % Female: 41.9% Mean Age (SD): 63 (4.8) y Race/ Ethnicity: NR Menopausal Status: Postmenopausal Obesity Status: All overweight or obese with BMI between 27 and 40 kg/m ² Mean BMI (SD): 31.3 (3.0) kg/m ² Income level: NR Education level: NR Mean physical activity level (SD): 916 (203) cpm	Intervention: High Protein diet Intended Protein Amount: 1.7 g/kg/d Carbohydrate: NR Fat: NR Baseline Protein Amount Mean (SD): 1.1 (0.4) g/kg/d; 14% of energy Carbohydrate Mean: 51% of energy Fat Mean: 31% of energy Actual Protein Amount at the end of study Mean: 1.69 g/kg/d; 34% of energy Carbohydrate Mean: 35% of energy	Intervention: High Protein diet How protein was administered: Provided 90% of diet and 2 supplements (20 g protein) per day to consume 1.7 g of protein/kg/day Protein Assessment Method: Baseline protein amount was derived from a validated 177-item food frequency questionnaire. Actual Protein Amount was derived from analysis of stored complete diet collected for each group throughout the intervention.	Muscle Strength - 1-RM leg press Measure/Method of Assessment: Maximum leg strength was assessed by 1-RM strength tests on leg press and leg strength machine Muscle Strength - 1-RM leg extension Measure/Method of Assessment: Maximum leg strength was assessed by 1-RM strength tests on leg press and leg strength machine

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Health status/ Comorbidities: Excluded renal insufficiency, type 1 or type 2 diabetes, cancer, COPD, previous gastric bypass Medication use: NR Supplement use: Excluded if used supplements or drugs known to interfere with energy balance used within 3 months prior Pregnant or lactating: NR</p> <p>Comparator: Normal Protein diet N: 30 % Female: 40% Mean Age (SD): 62 (4.8) y Race/ Ethnicity: NR Menopausal Status: Postmenopausal Obesity Status: All overweight or obese with BMI between 27 and 40 kg/m² Mean BMI (SD): 31.0 (2.9) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 825 (258) cpm Health status/ Comorbidities: Excluded renal insufficiency, type 1 or type 2 diabetes, cancer, COPD, previous gastric bypass Medication use: NR Supplement use: Excluded if used supplements or drugs known to interfere with energy balance used within 3 months prior</p>	<p>Fat Mean: 27% of energy</p> <p>Dietary Protein Intake Compliance (%): NR – high level of compliance stated for both intervention and comparator group</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Comparator: Normal Protein diet</p> <p>Intended Protein Amount: 0.9 g/kg/day Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 1.1 (0.4) g/kg/d; 14% of energy Carbohydrate Mean: 51% of energy Fat Mean: 31% of energy</p> <p>Actual Protein Amount at the end of study Mean: 0.92 g/kg/d; 19% of energy Carbohydrate Mean: 51% of energy Fat Mean: 24% of energy</p> <p>Dietary Protein Intake Compliance (%): NR – high level of compliance stated for both intervention and comparator group</p>	<p>Food diaries were used to assess the 10% diet chosen by the subjects.</p> <p>Dietary Protein Intake Compliance: Compliance was assured via daily contact (weekdays) with the investigators and dietitians.</p> <p>Comparator: Normal Protein diet</p> <p>How protein was administered: Provided 90% of diet and 2 supplements (25 g carbohydrates) per day to consume 0.9 g of protein/kg/day</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	<p>Muscle Strength - Handgrip Strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p> <p>Physical Performance - SPPB</p> <p>Measure/Method of Assessment: The SPPB consists of three components: balance, gait speed and chair rise ability</p> <p>Physical Performance - 400m walk speed Measure/Method of Assessment: The 400m walk test assessed the time it takes to walk 400m</p> <p>Muscle Mass - Lean body mass</p> <p>Measure/Method of Assessment: DXA (model DPX-L)</p> <p>Muscle Mass – Appendicular lean body mass/ skeletal muscle mass</p> <p>Measure/Method of Assessment: DXA (model DPX-L)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	Pregnant or lactating: NR	Protein type/source: Mixed Energy balance status: Hypocaloric Study duration: 12 weeks		
<p>PMID: 33975325 Englert 2021⁵⁷ Location/Country: Germany HDI: Very high Setting: Community dwelling Urban/Rural: NR Study design: RCT (parallel) Funding source: Academic, industry Risk of bias score: Low</p>	<p>Study of: Adults Total sample N: 54</p> <p>Intervention: High Protein N: 27 % Female: 100% Mean Age (SD): 59.0 (6) y Race/ Ethnicity: NR Menopausal Status: Postmenopausal Obesity Status: All women overweight, BMI ≥ 30 or ≥ 27 and waist circumference >88 cm Mean BMI (SD): 30.5 (2.8) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): PAL 1.4 (0.1) Health status/ Comorbidities: Excluded type 2 diabetes; thyroid disease; kidney, heart, or liver failure; neurological disease; electronic implants; active prostheses; life-sustaining electronic devices Medication use: Excluded medications like steroids, diuretics, thyroid drugs, statins, weight loss medication, beta blockers</p>	<p>Intervention: High Protein</p> <p>Intended Protein Amount: 1.5 g/kg/d Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of study Mean (SD): 113 (17) g/d Carbohydrate Mean (SD): 127 (18) g/d Fat Mean (SD): 46 (9) g/d</p> <p>Dietary Protein Intake Compliance (%): Compliance was the same in both intervention and comparator groups – good compliance rate stated for both intervention and comparator group</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Comparator: Normal Protein</p>	<p>Intervention: High Protein</p> <p>How protein was administered: 2 provided meal replacement shakes, 3rd meal and/or snack chosen from the individual's diet plan to reach 1.5 g of protein/kg/day</p> <p>Protein Assessment Method: Participants kept a food diary after the first and third session with dietitian for 7 consecutive days and food checklists on the remaining days. Dietary energy and macronutrient intake data were recorded in the first and third quarters of the intervention. The mean value for macronutrients was reported.</p> <p>Dietary Protein Intake Compliance: 4 nutrition training sessions for both groups separately and telephone interviews to enhance compliance</p> <p>Comparator: Normal Protein</p> <p>How protein was administered: 2 provided</p>	<p>Physical Performance - SPPB</p> <p>Measure/Method of Assessment: The SPPB consists of three components: balance, gait speed and chair rise ability</p> <p>Physical Performance - 400 m walk speed</p> <p>Measure/Method of Assessment: Walked as fast as they could without running for 400 meters</p> <p>Muscle Strength - Handgrip strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p> <p>Muscle Mass - Fat Free Mass</p> <p>Measure/Method of Assessment: BIA (seca mBCA 515/514)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Supplement use: Excluded protein supplementation during the last 3 months Pregnant or lactating: NR</p> <p>Comparator: Normal Protein N: 27 % Female: 100% Mean Age (SD): 58.7 (6) y Race/ Ethnicity: NR Menopausal Status: Postmenopausal Obesity Status: All women overweight, BMI ≥ 30 or ≥ 27 and waist circumference >88 cm Mean BMI (SD): 31.3 (4) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): PAL 1.4 (0.1) Health status/ Comorbidities: Excluded type 2 diabetes; thyroid disease; kidney, heart, or liver failure; neurological disease; electronic implants; active prostheses; life-sustaining electronic devices Medication use: Excluded medications like steroids, diuretics, thyroid drugs, statins, weight loss medication, beta blockers Supplement use: Excluded protein supplementation during the last 3 months Pregnant or lactating: NR</p>	<p>Intended Protein Amount: 0.8 g/kg/d Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of study Mean (SD): 63 (9) g/day Carbohydrate Mean (SD): 136 (29) g/day Fat Mean (SD): 48 (11) g/day</p> <p>Dietary Protein Intake Compliance (%): Compliance was the same in both intervention and comparator groups – good compliance rate stated for both intervention and comparator group</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Study duration: 12 weeks intervention, 6 months of follow-up</p>	<p>meal replacement shakes, 3rd meal and/or snack chosen from the individual's diet plan to reach 0.8 g of protein/kg/day</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	
<p>PMID: 20578205 Flechner-Mors</p>	<p>Study of: Adults Total sample N: 110</p>	<p>Intervention: High Protein</p>	<p>Intervention: High Protein</p>	<p>Muscle Mass – Fat-free mass</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>2010^{*32} Location/Country: Germany HDI: Very high Setting: Outpatient clinic Urban/Rural: NR Study Design: RCT (parallel) Funding source: Industry, academic Risk of bias score: High</p>	<p>Intervention: High Protein N: 55 % Female: 78.2% Mean Age (SD): 49.3 (12.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: Obese Mean BMI (SD): 36.2 (4.4) kg/m² Income level NR Education level: NR Physical activity level: Received instructions to maintain their usual physical activity during the study and not to undertake any new exercise programs, but exercise was not monitored Health status/ Comorbidities: Included: Those that met the criteria for metabolic syndrome Medication use: Exclude: anti-obesity medications Supplement use: NR Pregnant or lactating: Excluded</p> <p>Comparator: Conventional Diet N: 55% Female: 81.2% Mean Age (SD): 50 (13) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: Obese Mean BMI (SD): 36.3 (5.0) kg/m² Income level NR Education level: NR Physical activity level: Received instructions to</p>	<p>Intended Protein Amount: 1.34 g/kg/d; 30% of energy Carbohydrate: 40% of energy Fat: 30% of energy</p> <p>Baseline Protein Amount Mean (SD): 18.0 (4.9) % of energy; 72.7 (24.3) g/d Carbohydrate Mean (SD): 46.7 (9.4) % of energy; 194 (73) g/d Fat: 35.2 (7.6) % of energy; 64 (25) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 30.0 (7.0) % of energy; 92.2 (14.8) g/d Carbohydrate Mean (SD): 36.9 (7.9) % of energy; 119 (45) g/d Fat Mean (SD): 29.9 (5.7) % of energy; 42 (13) g/d</p> <p>Dietary Protein Intake Compliance (%): 56.3%</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Comparator: Conventional Diet</p> <p>Intended Protein Amount: 0.8 g/kg/d; 15% energy Carbohydrate: 30% energy Fat: 55% energy</p> <p>Baseline Protein Amount</p>	<p>How protein was administered: First 3 months: Consumed two protein-enriched meal replacements, one conventional meal, and two snacks as either a protein bar or a low-fat curd with fruit.</p> <p>After the first 3 months: Consumed one protein-enriched meal replacement, two meals, and two snacks</p> <p>Protein Assessment Method: Subjects kept 3-day food records at baseline, 3 months, 6 months, 9 months, and 12 months. Food quantities were recorded using standard household measures, and a trained assessment dietician reviewed the food records in person. Nutrient calculations were carried out using the PRODI program which is based on German food-composition tables.</p> <p>Dietary Protein Intake Compliance: Food records yielded data that revealed adherence to the dietary recommendations during the study</p> <p>Comparator: Conventional Diet</p>	<p>Measure/Method of Assessment: BIA (Bioimpedance Analyzer 450, Biodynamics, Seattle, Washington, USA)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>maintain their usual physical activity during the study and not to undertake any new exercise programs, but exercise was not monitored</p> <p>Health status/ Comorbidities: Included: Those that met the criteria for metabolic syndrome</p> <p>Medication use: Exclude: anti-obesity medications</p> <p>Supplement use: NR</p> <p>Pregnant or lactating: Excluded</p>	<p>Mean (SD): 17.0 (4.7) % of energy; 66.4 (22.7) g/d</p> <p>Carbohydrate Mean (SD): 48.2 (9.4) % of energy; 188 (64) g/d</p> <p>Fat Mean (SD): 34.6 (7.3) % of energy; 60 (26) g/d</p> <p>Actual Protein Amount at the end of the study</p> <p>Mean (SD): 21.4 (7.4) % of energy; 65.7 (14.7) g/d</p> <p>Carbohydrate Mean (SD): 47.6 (7.5) % of energy; 154 (44) g/d</p> <p>Fat: 29.6 (5.7) % of energy; 44 (16) g/d</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Study duration: 12 months</p>	<p>How protein was administered:</p> <p>First 3 months: Consumed three meals and two snacks with no replacements</p> <p>After 3 months: Consumed one standard meal replacement, two meals, and two snacks per day</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	
<p>PMID: 18371214</p> <p>Frestedt 2008³³</p> <p>Location/Country: USA</p> <p>HDI: Very high</p> <p>Setting: Community dwelling</p> <p>Urban/Rural: NR</p> <p>Study Design: RCT (parallel)</p> <p>Funding source: Industry</p> <p>Risk of bias score: High</p>	<p>Study of: Adults</p> <p>Total sample N: 59</p> <p>Intervention: Prolibra</p> <p>N: 31</p> <p>% Female: NR</p> <p>Mean Age (SE): 43.6 (1.1) y</p> <p>Race/ Ethnicity: NR</p> <p>Menopausal status: NR</p> <p>Obesity status: Yes</p> <p>Mean BMI (SE): 35.7 (0.7) kg/m²</p> <p>Income level NR</p> <p>Education level: NR</p>	<p>Intervention: Prolibra</p> <p>Intended Protein Amount: Supplement 20 g of protein/d (1-10g protein supplement twice daily); 15% of energy</p> <p>Carbohydrate: 55% of energy</p> <p>Fat: 30% of energy</p> <p>Baseline Protein Amount</p> <p>Mean (SD): 73 (3) g/d; 0.74 g/kg/d</p> <p>Carbohydrate Mean (SD): 222 (11) g/d</p>	<p>Intervention: Prolibra</p> <p>How protein was administered: One Prolibra supplement before breakfast and one before dinner. Each supplement contained 10 g of protein. Subjects were assigned a diet plan with a certain number of servings for various food groups similar to the standard paradigm set by the American Heart Association.</p>	<p>Muscle Mass - Lean muscle mass</p> <p>Measure/Method of Assessment: DXA (Lunar Prodigy Advance Plus, General Electric, Madison, WI)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Comparator: Placebo N: 28 % Female: NR Mean Age (SE): 42 (1.2) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: Yes Mean BMI (SE): 35.4 (0.7) kg/m² Income level NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Fat Mean (SD): 75 (5) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 0.81 g/kg/d (with supplement); 0.60 g/kg/d and 57 (3) g/d (w/o supplement) Carbohydrate Mean (SD): 178 (8) g/d (w/o supplement) Fat Mean (SD): 49 (3) g/d (w/o supplement)</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Animal; whey protein</p> <p>Energy balance status: Hypocaloric</p> <p>Comparator: Placebo</p> <p>Intended Protein Amount: 15% of energy Carbohydrate: 55% of energy Fat: 30% of energy</p> <p>Baseline Protein Amount Mean (SD): 74 (4) g/d; 0.76 g/kg/d Carbohydrate Mean (SD): 211 (10) g/d Fat Mean (SD): 71 (5) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 0.61 g/kg/d (with supplement); 58 (2) g/d (w/o supplement) Carbohydrate Mean (SD): 182 (9) g/d (w/o supplement)</p>	<p>Protein Assessment Method: Total protein in Prolibra was measuring using Kjeldahl (AOAC 945.01). Subjects completed diet diaries on at least 5 days each month.</p> <p>Dietary Protein Intake Compliance: Compliance was assessed by supplement count and diet diary review. Participants were also contacted by telephone between visits to review diet and supplement compliance.</p> <p>Comparator: Placebo</p> <p>How protein was administered: Subjects received an iso-caloric beverage containing maltodextrin. Subjects were assigned a diet plan with a certain number of servings for various food groups similar to the standard paradigm set by the American Heart Association.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
		Fat Mean (SD): 47 (3) g/d (w/o supplement) Dietary Protein Intake Compliance (%): NR Protein type/source: Mixed Energy balance status: Hypocaloric Study duration: 12 weeks		
PMID: 34208986 Haghighat 2021 ⁵⁸ Location/Country: Iran HDI: High Setting: Community dwelling Urban/Rural: NR Study design: RCT (parallel) Funding source: Academic Risk of bias score: Moderate	Study of: Adults Total sample N: 120 Intervention: High Protein N: 60 % Female: 100% Mean Age (SD): 24 (3) y (total sample average) Race/ Ethnicity: NR Menopausal Status: Premenopausal Obesity Status: Normal weight obesity (body fat percentage >30%) Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: 26% low, 63% moderate Health status/ Comorbidities: Excluded history or presence of bariatric surgery, any acute or chronic diseases, psychiatric disorders Medication use: Excluded "medication use" Supplement use: Excluded those that consumed more than 300 mg of caffeine daily	Intervention: High Protein Intended Protein Amount: 18.2 g of protein during snack, no goal for total dietary protein Carbohydrate: NR Fat: NR Baseline Protein Amount Mean (SD): 51.37 (7.36) g/d; 0.84 (0.15) g/kg/d Carbohydrate Mean (SD): 253.48 (39.24) g/d Fat Mean (SD): 48.87 (5.42) g/d Actual Protein Amount at the end of the study Mean (SD): 74.94 (6.40) g/d; 1.28 (0.2) g/kg/d Carbohydrate Mean (SD): 195.04 (33.47) g/d Fat Mean (SD): 45.88 (8.37) g/d Dietary Protein Intake Compliance (%): 86.6% Protein type/source: Plant	Intervention: High Protein How protein was administered: High protein content snack (50 g of soybeans equaling 18.2 g protein) daily at 10 a.m. Protein Assessment Method: 24-h dietary recalls were completed by all participants on three occasions over a week time period (one weekday and two weekend days) prior to and at the end of study. Calorie and macronutrient combinations were assessed using the Nutritionist IV for Windows software program (The Hearst Corporation, San Bruno, CA) Dietary Protein Intake Compliance: Laboratory on two other occasions (at the end of months 2 and 4) to report snack compliance. Additional snack compliance	Muscle Mass - Skeletal Muscle Mass Measure/Method of Assessment: BIA (SECA Model 222; Seca, Germany)

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Pregnant or lactating: Excluded</p> <p>Comparator: Low Protein N: 60 % Female: 100% Mean Age (SD): 24 (3) y (total sample average) Race/ Ethnicity: NR Menopausal Status: Premenopausal Obesity Status: Normal weight obesity (body fat percentage >30%) Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: 31% low, 69% moderate Health status/ Comorbidities: Excluded history or presence of bariatric surgery, any acute or chronic diseases, psychiatric disorders Medication use: Excluded "medication use" Supplement use: Excluded those that consumed more than 300 mg of caffeine daily Pregnant or lactating: Excluded</p>	<p>Energy balance status: Eucaloric</p> <p>Comparator: Low Protein</p> <p>Intended Protein Amount: <2 g of protein during snack, no goal for total dietary protein Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 48.80 (7.21) g/d; 0.79 (0.14) g/kg/d Carbohydrate Mean (SD): 247.05 (57.55) g/d Fat Mean (SD): 46.36 (7.97) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 55.02 (6.30) g/d; 0.87 (0.12) g/kg/d Carbohydrate Mean (SD): 253.45 (55.55) g/d Fat Mean (SD): 50.91 (9.56) g/d</p> <p>Dietary Protein Intake Compliance (%): 91.6%</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 6 months</p>	<p>reporting was performed once per week by phone or WhatsApp software.</p> <p>Comparator: Low Protein</p> <p>How protein was administered: Low protein content snack (~3.5 servings of fruit equaling <2 g protein) daily at 10 a.m.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	
<p>PMID: 24047916 Jesudason 2013^{*4}</p>	<p>Study of: Adults Total sample N: 323</p>	<p>Intervention: High protein</p>	<p>Intervention: High protein</p>	<p>Muscle Mass - Lean Mass</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>Location/Country: Australia HDI: Very high Setting: Community dwelling Urban/Rural: NR Study Design: RCT (Parallel) Funding source: Government Risk of bias score: High</p>	<p>Intervention: High protein N: 164 % Female: 100% Mean Age (SE): 59.5 (0.4) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Pubertal status: NA Obesity status: Obese Mean BMI (SD): 34.0 (0.4) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/Co-morbidities: Subjects with parathyroid disease, a vitamin D concentration, 60 nmol/L with secondary hyperparathyroidism, or unstable metabolic, cardiac, gastrointestinal, renal, or other significant disease, including malignancies, were excluded Medication use: Women were ineligible if they were taking hormone-replacement therapy, bisphosphonates, steroids, diuretics, calcium, or vitamin D Supplement use: Women were ineligible if they were taking calcium or vitamin D Pregnant or lactating: NA</p> <p>Comparator: Normal protein N: 159 % Female: 100% Mean Age (SD): 59.4 (0.4) y Race/Ethnicity: NR</p>	<p>Intended Protein Amount: 32% of energy Carbohydrate: 44% of energy Fat: 24% of energy</p> <p>Baseline Protein Amount Mean (SD): 92.5 (2.2) g/day; 18.6 (0.2) % of energy Carbohydrate Mean (SD): 230 (6) g/day; 42.9 (0.5) % of energy Fat Mean (SD): 79.2 (2.7) g/day; 33.3 (0.4) % of energy</p> <p>Actual Protein Amount at the end of the study Mean (SD): 91.5 (2.2) g/day; 21.9 (0.3) % of energy Carbohydrate Mean (SD): 196 (6) g/day; 43.9 (0.7) % of energy Fat Mean (SD): 55.5 (2.3) g/day; 28.2 (0.7) % of energy</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Comparator: Normal protein</p> <p>Intended Protein Amount: 22% of energy Carbohydrate: 55% of energy Fat: 23% of energy</p> <p>Baseline Protein Amount Mean (SD): 91.2 (1.9) g/day; 18.4 (0.2) % of energy</p>	<p>How protein was administered: Participants received monthly group dietetic education and support for the first 6 months and then every 3 months for the next 18 months. Sample food packs of \$20 vouchers were provided to participants at baseline and 12 and 26 weeks. Each diet group was allocated to a protein target that was based on key protein foods as a compliance measure.</p> <p>Protein Assessment Method: Participants recorded dietary intakes using a protein counter and checklist. Protein compliance checklists were collected from each participant at each group session. Subjects also completed a FFQ at baseline and 1 and 2 y.</p> <p>Dietary Protein Intake Compliance: Compliance was assessed by (1) blood urea nitrogen and 24h urine for urea nitrogen excretion (2) allocated to a protein target for each diet group and (3) protein-compliance checklists were collected from each participant at each group session.</p> <p>Comparator: Normal protein</p>	<p>Measures/Method of Assessment: NR</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Menopausal status: Postmenopausal Pubertal status: NA Obesity status: Obese Mean BMI at baseline: 33.4 (0.4) kg/m² Income level: NR Education level: NR Physical activity level: NR Health status/Co-morbidities: Subjects with parathyroid disease, a vitamin D concentration, 60 nmol/L with secondary hyperparathyroidism, or unstable metabolic, cardiac, gastrointestinal, renal, or other significant disease, including malignancies, were excluded Medication use: Women were ineligible if they were taking hormone-replacement therapy, bisphosphonates, steroids, diuretics, calcium, or vitamin D Supplement use: Women were ineligible if they were taking calcium or vitamin D Pregnant or lactating: NA</p>	<p>Carbohydrate Mean (SD): 228 (5) g/day; 42.9 (0.5) % of energy Fat Mean (SD): 77.7 (2.1) g/day; 33.4 (0.4) % of energy Actual Protein Amount at the end of the study Mean (SD): 80.6 (2.2) g/day; 18.9 (0.3) % of energy Carbohydrate Mean (SD): 214 (5) g/day; 47.2 (0.6) % of energy Fat Mean (SD): 57.9 (2.5) g/day; 28.6 (0.7) % of energy Dietary Protein Intake Compliance (%): NR Protein type/source: Mixed Energy balance status: Hypocaloric Study duration: 24 months</p>	<p>How protein was administered: Participants received monthly group dietetic education and support for the first 6 months and then every 3 months for the next 18 months. Sample food packs of \$20 vouchers were provided to participants at baseline and 12 and 26 weeks. Each diet group was allocated to a protein target that was based on key protein foods as a compliance measure.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	
<p>PMID: 25844619 Kerstetter 2015*#⁵ Location/Country: USA HDI: Very high Setting: NR Urban/ Rural: NR Study design: RCT (parallel) Funding source: Government, academic Risk of bias score: Low</p>	<p>Study of: Adults Total sample N: 208 Intervention: High Protein N: 106 % Female: 84% Mean Age (SD): 69.9 (6.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR</p>	<p>Intervention: High Protein Intended Protein Amount: 40 g of protein from the supplement; total daily protein goal NR Carbohydrate: Test food protein NR Fat: Test food protein NR Baseline Protein Amount</p>	<p>Intervention: High Protein How protein was administered: Participants received a dietary whey protein supplement (protein group; Provon 290; Glambia Nutritionals) that was closely matched for composition, color, kilocalories, sodium,</p>	<p>Muscle Mass - Total lean body mass Measure/Method of Assessment: DXA using either a Hologic 4500W machine (Yale University School of Medicine) or a Lunar Prodigy DPX-IQ (University of Connecticut Health Center)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Mean BMI (SD): 26.1 (3.4) kg/m² Income level: NR Education level: NR Mean physical activity level score (SD): 6.7 (2.1) Health status/ Comorbidities: Healthy older adults Medication use: Excluded if using long-term chemotherapeutic drugs, aromatase inhibitors or tamoxifen, methotrexate, phenytoin, phenobarbital or inhaled corticosteroids (greater than 800 ug/day), actively being treated for leukemia or multiple myeloma, a change in thyroid medications, medications known to affect calcium metabolism or use of proton pump inhibitors twice daily Supplement use: Daily multivitamin mineral supplement (contained 400 IU of vitamin D); Ca carbonate supplement (300 mg tablets) Pregnant or lactating: NR</p> <p>Comparator: Low Protein N: 102 % Female: 87.3% Mean Age (SD): 70.5 (6.4) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.4 (4.0) kg/m² Income level: NR Education level: NR</p>	<p>Least Square Mean (SEM): 73.8 (1.9) g/d Carbohydrate Least Square Mean (SEM): 214.1 (5.2) g/d Fat Least Square Mean (SEM): 59.4 (2.1) g/d</p> <p>Actual Protein Amount at the end of the study Least Square Mean (SEM): 90.7 (3.3) g/d Carbohydrate Least Square Mean (SEM): 196.9 (6.6) g/d Fat Least Square Mean (SEM): 55.6 (2.0) g/d</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Animal; whey supplement</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Low Protein</p> <p>Intended Protein Amount: Test food protein NR Carbohydrate: Test food protein NR Fat: Test food protein NR</p> <p>Baseline Protein Amount Least Square Mean (SEM): 72.9 (1.8) g/d; 1.06 (0.03) g/kg/d (total daily) Carbohydrate Least Square Mean (SEM): 206.2 (5.8) g/d (total daily)</p>	<p>potassium, phosphorus, fiber, and calcium.</p> <p>Protein Assessment Method: Participants completed a 3-day food record prior to baseline, 6 months, and 18 months and were analyzed using the ESHA Food Processor software program (ESHA Research; version 10.1.0).</p> <p>Dietary Protein Intake Compliance: Urinary area was a compliance measure.</p> <p>Comparator: Low Protein</p> <p>How protein was administered: Participants received a maltodextrin supplement Maltrin M100; Grain Processing Corp) that was closely matched for composition, color, kilocalories, sodium, potassium, phosphorus, fiber, and calcium.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Mean physical activity level score (SD): 6.8 (1.9) Health status/ Comorbidities: Healthy older adults Medication use: Excluded if using long-term chemotherapeutic drugs, aromatase inhibitors or tamoxifen, methotrexate, phenytoin, phenobarbital or inhaled corticosteroids (greater than 800 ug/day), actively being treated for leukemia or multiple myeloma, a change in thyroid medications, medications known to affect calcium metabolism or use of proton pump inhibitors twice daily Supplement use: Daily multivitamin mineral supplement (contained 400 IU of vitamin D); Ca carbonate supplement (300 mg tablets) Pregnant or lactating: NR</p>	<p>Fat Least Square Mean (SEM): 61.3 (2.5) g/d (total daily) Actual Protein Amount at end of the study Least Square Mean (SEM): 72.7 (2.4) g/d; 1.05 (0.04) g/kg/d (total daily) Carbohydrate Least Square Mean (SEM): 229.0 (9.5) g/d (total daily) Fat Least Square Mean (SEM): 58.8 (2.4) g/d (total daily) Dietary Protein Intake Compliance (%): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 18 months</p>		
<p>PMID: 37739678 Kruger 2023⁵⁹ Location/Country: New Zealand HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: RCT (parallel) Funding source: Industry Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 114 Whole cohort N: 103 % Female: 100% Mean Age (SD):70.1 (3.51) y Race/ Ethnicity: 89% New Zealand European Menopausal Status: NR Obesity Status: NR Mean BMI (SD): 24.8 (2.65) kg/m² Income level: NR Education level:</p>	<p>Intervention 1: Deer Milk Intended Protein Amount: Protein supplement contained 15.0 g of protein per 200 ml Carbohydrate: Supplement contained 9.0 g of carbohydrate per 200 ml Fat: Supplement contained 19.6 g of fat per 200 ml Baseline Protein Amount (whole cohort): <1 g/kg: 29% 1-3 g/kg: 39%</p>	<p>Intervention 1: Deer Milk How protein was administered: Participants consumed 200 ml of deer milk Protein Assessment Method: Habitual dietary intake data was collected by 3-day estimated food diary at baseline. Average energy and macronutrient intake was assessed using FoodWorks Professional Edition 10.</p>	<p>Muscle Mass - Fat-free mass Measure/Method of Assessment: BIA (Inbody 320, Seoul, Korea) Muscle Mass – Skeletal muscle mass Measure/Method of Assessment: BIA (Inbody 320, Seoul, Korea)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Tertiary level of education: 34%</p> <p>Percent physical activity level:</p> <p>Light: 38%</p> <p>Moderate: 55%</p> <p>Vigorous: 7%</p> <p>Health status/ Comorbidities:</p> <p>History of cancer: 18%</p> <p>Cardiovascular disease: 8%</p> <p>Hypertension: 24%</p> <p>Hypercholesterolemia: 30%</p> <p>Musculoskeletal conditions: 27%</p> <p>Diabetes: 1%</p> <p>Gastrointestinal conditions: 16%</p> <p>Respiratory conditions: 8%</p> <p>Renal diseases: 1%</p> <p>Thyroid diseases: 6%</p> <p>Autoimmune diseases: 3%</p> <p>Psychological conditions: 16%</p> <p>Medication use: Cholesterol medication: 14%</p> <p>Supplement use: NR</p> <p>Pregnant or lactating: NR</p>	<p>≥1.3 g/kg: 32%</p> <p>Carbohydrate Mean (SD): NR</p> <p>Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study</p> <p>Mean (SD): NR</p> <p>Carbohydrate Mean (SD) NR</p> <p>Fat Mean (SD): NR</p> <p>Dietary Protein Intake</p> <p>Compliance (%): 98.7%</p> <p>Protein type/source: Animal</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Oral Nutritional Supplement</p> <p>Intended Protein Amount:</p> <p>Protein supplement contained 12.0 g of protein per 200 ml</p> <p>Carbohydrate: Supplement contained 36.8 g of carbohydrate per 200 ml</p> <p>Fat: Supplement contained 11.6 g of fat per 200 ml</p> <p>Baseline Protein Amount (whole cohort):</p> <p><1 g/kg: 29%</p> <p>1-3 g/kg: 39%</p> <p>≥1.3 g/kg: 32%</p> <p>Carbohydrate Mean (SD): NR</p> <p>Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study</p> <p>Mean (SD): NR</p>	<p>Dietary Protein Intake Compliance: Throughout the study period, participants were also asked to complete a diary to record consumption of the beverages.</p> <p>Comparator: Oral Nutritional Supplement</p> <p>How protein was administered: Participants consumed 200 ml of oral nutritional supplement</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	<p>Muscle Strength - Handgrip strength</p> <p>Measure/Method of Assessment: Hand dynamometer</p> <p>Muscle Strength - Chair stand test</p> <p>Measure/Method of Assessment: Maximum number of chair stand repetitions possible in 30 s period was recorded</p> <p>Physical Performance - 40 m fast-paced walk test</p> <p>Measure/Method of Assessment: Fast-paced walking was timed over 4 x 10 m for a total of 40 m.</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
		Carbohydrate Mean (SD) NR Fat Mean (SD): NR Dietary Protein Intake Compliance (%): 96.8% Protein type/source: Animal Energy balance status: Eucaloric Study duration: 11 weeks		
PMID: 33612439 Li 2021⁶⁰ Location/Country: China HDI: High Setting: Community dwelling Urban/ Rural: Urban Study design: RCT (parallel) Funding source: Nonprofit, government, academic Risk of bias score: Low	Study of: Adults Total sample N: 123 Intervention 1: Whey Protein N: 31 % Female: 48.4% Mean Age (SD): 71 (4) y Race/ Ethnicity: NR Menopausal Status: NR Obesity Status: NR Mean BMI (SD): 21.8 (2.0) kg/m ² Income level: NR Education level: High school or below: 67.7% College or above: 32.3% Mean physical activity level (SD): 38.8 (13.0) MET-h/d Health status/ Comorbidities: Low lean muscle mass; excluded disease with movement disorders such as stroke, fracture, and arthritis; previous osteoporotic fracture or joint replacement; musculoskeletal injuries; allergies to whey or soy protein supplements	Intervention 1: Whey Protein Intended Protein Amount: Protein supplement contained 7.98 g of protein; dosage intended to increase participant protein consumption to 1.5 g/kg/d Carbohydrate: NR Fat: NR Baseline Protein Amount Mean (SD): 62.7 (20.7) g/d; 1.14 (0.36) g/kg/d Carbohydrate Mean (SD): 200.9 (65.9) g/d Fat Mean (SD): 56.0 (21.2) g/d Actual Protein Amount at the end of the study Mean (SD): 75.3 (13.8) g/d; 1.39 (0.24) g/kg/d (total) Carbohydrate Mean (SD): 185.5 (43.1) g/d Fat Mean (SD): 50.1 (11.7) g/d Dietary Protein Intake Compliance (%): 99%	Intervention 1: Whey Protein How protein was administered: Participants consumed a whey protein supplement twice daily Protein Assessment Method: Measured at baseline and at 6 months using a 79-item semi quantitative FFQ. Baseline FFQ was used to collect dietary intake in the past year. FFQ at 6 months was used to collect the dietary intake during the 6-month intervention. Daily dietary intakes calculated based on the China Food Composition Table 2004. Dietary Protein Intake Compliance: For Whey Protein, Soy Protein, and Whey- Soy protein groups compliance was assessed by counting the number of	Muscle Mass - Total body lean mass Measure/Method of Assessment: DXA (Discovery W; Hologic Inc) Muscle Mass - Appendicular lean mass/ skeletal muscle mass Measure/Method of Assessment: DXA (Discovery W; Hologic Inc) Muscle Mass – Appendicular skeletal muscle index Measure/Method of Assessment: Appendicular lean mass divided by height squared Muscle Strength - Handgrip strength Measure/Method of Assessment: Measured using handgrip dynamometer

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Medication use: NR Supplement use: Excluded those that used protein and antioxidant supplements within the past 12 months prior to enrollment Pregnant or lactating: NR</p> <p>Intervention 2: Soy Protein N: 31 % Female: 51.6% Mean Age (SD): 69 (4) y Race/ Ethnicity: NR Menopausal Status: NR Obesity Status: NR Mean BMI (SD): 21.2 (2.3) kg/m² Income level: NR Education level: High school or below: 58% College or above: 42% Mean physical activity level (SD): 35.5 (15.7) MET-h/d Health status/ Comorbidities: Low lean muscle mass; excluded disease with movement disorders such as stroke, fracture, and arthritis; previous osteoporotic fracture or joint replacement; musculoskeletal injuries; allergies to whey or soy protein supplements Medication use: NR Supplement use: Excluded those that used protein and antioxidant supplements within the past 12 months prior to enrollment Pregnant or lactating: NR</p>	<p>Protein type/source: Animal; whey</p> <p>Energy balance status: Eucaloric</p> <p>Intervention 2: Soy Protein</p> <p>Intended Protein Amount: Protein supplement contained 8.80 g of protein; dosage intended to increase participant protein consumption to 1.5 g/kg/d Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 59.6 (19.1) g/d; 1.11 (0.33) g/kg/d Carbohydrate Mean (SD): 191.9 (56.5) g/d Fat Mean (SD): 52.8 (26.8) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 79.3 (20.5) g/d; 1.51 (0.41) g/kg/d (total) Carbohydrate Mean (SD): 195.7 (34.3) g/d Fat Mean (SD): 50.8 (16.8) g/d</p> <p>Dietary Protein Intake Compliance (%): 91.5%</p> <p>Protein type/source: Plant; soy</p> <p>Energy balance status: Eucaloric</p>	<p>protein packets returned by the participants.</p> <p>Intervention 2: Soy Protein</p> <p>How protein was administered: Participants consumed a soy protein supplement twice daily</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p> <p>Intervention 3: Whey-soy protein group</p> <p>How protein was administered: Participants consumed a whey-soy supplement (1:1 ratio) twice daily</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p> <p>Comparator: Control</p> <p>How protein was administered: Participants consumed habitual diet</p> <p>Protein Assessment Method: Same as above</p>	<p>Physical Performance - 4 m gait speed</p> <p>Measure/Method of Assessment: Walk 8m at usual pace and time used for walking through the central 4 m was measured</p> <p>Muscle Strength - Chair stand test</p> <p>Measure/Method of Assessment: Participants to stand up from a chair and sit down 5 times as quickly as possible with arms folded across their chests.</p> <p>Physical Performance - SPPB</p> <p>Measure/Method of Assessment: The SPPB consists of three components: balance, gait speed and chair rise ability</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Intervention 3: Whey-Soy protein group N: 31 % Female: 45.2% Mean Age (SD): 70 (4) y Race/ Ethnicity: NR Menopausal Status: NR Obesity Status: NR Mean BMI (SD): 20.6 (1.8) kg/m² Income level: NR Education level: High school or below: 54.8% College or above: 45.2% Mean physical activity level (SD): 38.9 (11.5) MET-h/d Health status/ Comorbidities: Low lean muscle mass; excluded disease with movement disorders such as stroke, fracture, and arthritis; previous osteoporotic fracture or joint replacement; musculoskeletal injuries; allergies to whey or soy protein supplements Medication use: NR Supplement use: Excluded those that used protein and antioxidant supplements within the past 12 months prior to enrollment Pregnant or lactating: NR</p> <p>Comparator: Control N: 30 % Female: 56.7% Mean Age (SD): 71 (4) y Race/ Ethnicity: NR Menopausal Status: NR Obesity Status: NR</p>	<p>Intervention 3: Whey-Soy protein group</p> <p>Intended Protein Amount: Protein supplement contained 8.39 g of protein; dosage intended to increase participant protein consumption to 1.5 g/kg/d Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 61.1 (19.1) g/d; 1.14 (0.37) g/kg/d Carbohydrate Mean (SD): 188.6 (50.9) g/d Fat Mean (SD): 51.7 (19.5) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 80.2 (18.2) g/d; 1.49 (0.34) g/kg/d (total) Carbohydrate Mean (SD): 197.5 (51.8) g/d Fat Mean (SD): 51.1 (16.9) g/d</p> <p>Dietary Protein Intake Compliance (%): 94.5%</p> <p>Protein type/source: Mixed; whey and soy (1:1 ratio)</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Control</p>	<p>Dietary Protein Intake Compliance: Same as above</p>	

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Mean BMI (SD): 20.8 (2.2) kg/m² Income level: NR Education level: High school or below: 63.3% College or above: 36.7% Mean physical activity level (SD): 33 (14) MET-h/d Health status/ Comorbidities: Low lean muscle mass; excluded disease with movement disorders such as stroke, fracture, and arthritis; previous osteoporotic fracture or joint replacement; musculoskeletal injuries; allergies to whey or soy protein supplements Medication use: NR Supplement use: Excluded those that used protein and antioxidant supplements within the past 12 months prior to enrollment Pregnant or lactating: NR</p>	<p>Intended Protein Amount: Followed habitual diet; total daily protein goal NR Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 59.3 (18.8) g/d; 1.17 (0.30) g/kg/d Carbohydrate Mean (SD): 221 (45.4) g/d Fat Mean (SD): 49.0 (17.3) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 56.3 (11.0) g/d; 1.11 (0.25) g/kg/d (total) Carbohydrate Mean (SD): 212.0 (88.1) g/d Fat Mean (SD): 49.0 (11.3) g/d</p> <p>Dietary Protein Intake Compliance (%): NA</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 6 months</p>		
<p>PMID: 33871558 Murphy 2021^{*36} Location/Country: Ireland HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study design: RCT (parallel) Funding source:</p>	<p>Study of: Adults Total sample N: 107</p> <p>Intervention 1: Leucine-enriched Protein N: 38 % Female: 52.6% Mean Age (SD): 70 (5) y Race/Ethnicity: 100% White</p>	<p>Intervention 1: Leucine-enriched Protein</p> <p>Intended Protein Amount: 21.2 g in supplemental protein per day; total intake goals NR Carbohydrate: NR Fat: NR</p>	<p>Intervention 1: Leucine-enriched Protein</p> <p>How protein was administered: Two supplements daily equaling 21.2 g protein per day (including 6.2 g leucine); one was consumed before</p>	<p>Muscle Mass - Adjusted appendicular lean mass/ skeletal Muscle Mass</p> <p>Measure/Method of Assessment: DXA (GE-LUNAR iDXA; Aymes Medical)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>Government Risk of bias score: High</p>	<p>Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.8 (3.4) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 8354 (4125) steps/day Health status/ Comorbidities: Included: Low skeletal muscle mass; generally healthy according to responses to a standard health screening questionnaire Excluded: malignancy in the past 5 years, diabetes, advanced renal disease, neuromuscular disease, total walking incapacity Medication use: Mean (SD) number of medications: 1 (2); Excluded if taking medications that interfere with the nutrition intervention - corticosteroids for systemic use, hormone replacement therapy, insulin, high-dose anti-inflammatories, simvastatin Supplement use: Excluded if consumed LC n-3 PUFA supplementation and were not willing to cease consumption ≥ 6 weeks prior to and for the duration of the 24-wk study Pregnant or lactating: NR</p> <p>Intervention 2: Leucine-enriched Protein+ PUFAs N: 38</p>	<p>Baseline Protein Amount Mean (SD): 84 (26) g/d; 17.1 (3.9) % of energy Carbohydrate Mean (SD): 226 (78) g/d; 45.0 (9.7) % of energy Fat Mean (SD): 82 (32) g/d; 36.3 (7.7) % of energy</p> <p>Actual Protein Amount at the end of the study Mean (SD): 100 (23) g/d; 19.6 (3.3) % of energy Carbohydrate Mean (SD): 229 (60) g/d; 44.6 (6.7) % of energy Fat Mean (SD): 80 (24) g/d; 34.8 (6.3) % of energy</p> <p>Dietary Protein Intake Compliance (%): Median (IQR): 89% (83-94%)</p> <p>Protein type/source: Whey protein and a peptide carrier enriched with free leucine</p> <p>Energy balance status: Eucaloric</p> <p>Intervention 2: Leucine-enriched Protein +PUFAS</p> <p>Intended Protein Amount: 21.2 g in supplemental protein per day; total intake goals NR Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 77 (25) g/d; 17.6 (4.5) % of energy</p>	<p>breakfast and one before their second light meal of the day with habitual diet</p> <p>Protein Assessment Method: Dietary intake was assessed via a 24-h recall using the 5-step multiple-pass method at pre-, mid-, and post intervention visits</p> <p>Dietary Protein Intake Compliance: Compliance was derived using the self-report supplement logs</p> <p>Intervention 2: Normal Protein</p> <p>How protein was administered: Two supplements daily equaling 21.2 g protein per day (including 6.2 g leucine and 4 g LC n-3 PUFAs); one was consumed before breakfast and one before their second light meal of the day with habitual diet</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p> <p>Comparator: Normal Protein</p> <p>How protein was administered: Isocaloric maltodextrin supplement</p>	<p>Muscle Strength - Handgrip strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p> <p>Muscle Strength - Isometric knee extension peak torque</p> <p>Measure/Method of Assessment: Self-reported dominant leg using a dynamometer; warm-up and 4 maximal leg extensions at 90 degrees with 60s between (also did 3 rounds at 60 degrees and 120 degrees); highest result used in analysis</p> <p>Muscle Strength - Isometric knee flexion peak torque</p> <p>Measure/Method of Assessment: Self-reported dominant leg using a dynamometer; warm-up and 4 maximal leg flexion at 90 degrees with 60s between; highest result used in analysis</p> <p>Physical Performance - SPPB</p> <p>Measure/Method of Assessment: The SPPB consists of three components: balance, gait speed and chair rise ability</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>% Female: 55.3% Mean Age (SD): 73 (6) y Race/Ethnicity: 100% White Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.7 (3.2) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 8257 (3906) steps/day Health status/ Comorbidities: Included: Low skeletal muscle mass; generally healthy according to responses to a standard health screening questionnaire Excluded: malignancy in the past 5 years, diabetes, advanced renal disease, neuromuscular disease, total walking incapacity Medication use: Mean (SD) number of medications: 2 (2); Excluded if taking medications that interfere with the nutrition intervention - corticosteroids for systemic use, hormone replacement therapy, insulin, high-dose anti-inflammatories, simvastatin Supplement use: Excluded if consumed LC n-3 PUFA supplementation and were not willing to cease consumption ≥ 6 weeks prior to and for the duration of the 24-wk study Pregnant or lactating: NR</p>	<p>Carbohydrate Mean (SD): 200 (66) g/d; 45.6 (8.4) % of energy Fat Mean (SD): 69 (25) g/d; 35.4 (8.8) % of energy Actual Protein Amount at the end of the study Mean (SD): 92 (25) g/d; 19.9 (4.0) % of energy Carbohydrate Mean (SD): 200 (57) g/d; 43.5 (8.0) % of energy Fat Mean (SD): 76 (28) g/d; 36.2 (7.8) % of energy Dietary Protein Intake Compliance (%): Median (IQR): 92% (87-97%) Protein type/source: Animal; whey protein and a peptide carrier enriched with free leucine Energy balance status: Eucaloric Comparator: Normal Protein Intended Protein Amount: NR Carbohydrate: NR Fat: NR Baseline Protein Amount Mean (SD): 79 (34) g/d; 16.7 (5.3) % of energy Carbohydrate Mean (SD): 214 (62) g/d; 45.6 (7.5) % of energy Fat Mean (SD): 80 (34) g/d; 37.4 (9.3) % of energy</p>	<p>Protein Assessment Method: Same as above Dietary Protein Intake Compliance: Same as above</p>	<p>Physical Performance - Gait speed Measure/Method of Assessment: Per standard SPPB protocols Physical Performance - TUG Measure/Method of Assessment: Per standard protocols; repeated twice with the average of the tests used in analysis Muscle Strength- 5 times sit-to-stand Method/Measure of Assessment: Per standard SPPB protocols</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Comparator: Normal Protein N: 31 % Female: 45.2% Mean Age (SD): 73 (7) y Race/Ethnicity: 100% White Menopausal status: NR Obesity status: NR Mean BMI (SD): 25.4 (2.8) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 8192 (5142) steps/day Health status/ Comorbidities: Included: Low skeletal muscle mass; generally healthy according to responses to a standard health screening questionnaire Excluded: malignancy in the past 5 years, diabetes, advanced renal disease, neuromuscular disease, total walking incapacity Medication use: Mean (SD) number of medications: 2 (3); Excluded if taking medications that interfere with the nutrition intervention - corticosteroids for systemic use, hormone replacement therapy, insulin, high-dose anti-inflammatories, simvastatin Supplement use: Excluded if consumed LC n-3 PUFA supplementation and were not willing to cease consumption \geq 6 weeks prior to and for the duration of the 24-wk study</p>	<p>Actual Protein Amount at the end of the study Mean (SD): 83 (23) g/d; 15.2 (3.2) % of energy Carbohydrate Mean (SD): 268 (68) g/d; 49.8 (5.6) % of energy Fat Mean (SD): 85 (30) g/d; 34.8 (5.4) % of energy</p> <p>Dietary Protein Intake Compliance (%): Median (IQR): 93% (87-95%)</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 24 weeks</p>		

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	Pregnant or lactating: NR			
PMID: 34098214 Peng 2021 ^{*37} Location/Country: Taiwan/China HDI: High Setting: Community dwelling Urban/ Rural: NR Study design: RCT (parallel) Funding source: Academic, industry Risk of bias score: High	Study of: Adults Total sample N: 52 Intervention: High Protein N: 27 % Female: 48.1% Mean Age (SD): 53.4 (8.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 25.1 (3.9) kg/m ² Income level: NR Mean education level (SD): 14.1 (2.9) y Mean physical activity level (SD): 1567.3 (1244.9) kcal/wk Health status/ Comorbidities: Excluded: (1) history of fracture or severe arthritis in recent 6 months, (2) known history of chronic kidney disease stage III and over, i.e. estimated glomerular filtered rate (eGFR) < 60 ml/min/1.73 m ² , (3) contraindicated for magnetic resonance imaging, (4) using anabolic hormones in the past 3 months, (5) were disability or limited functional ability, (6) having advanced, active or uncontrolled diseases, and (6) dementia, cognitive impairment or other sensory impairment that limited communication and understanding of the study	Intervention: High Protein Intended Protein Amount: 25% of energy Carbohydrate: NR Fat: NR Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Actual Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Dietary Protein Intake Compliance (%): 91.2% Protein type/source: Mixed Energy balance status: Eucaloric Comparator: Normal Protein Intended Protein Amount: 15% of energy Carbohydrate: NR Fat: NR Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Actual Protein Amount at the end of the study	Intervention: High Protein How protein was administered: Received 10 frozen meals per week for 12 weeks containing 25% energy in protein. Protein Assessment Method: NR Dietary Protein Intake Compliance: Insufficient compliance to the study protocol (e.g low meal complete rate and vigorous changes of lifestyle) Comparator: Normal Protein How protein was administered: Received 10 frozen meals per week for 12 weeks containing 15% energy in protein. Protein Assessment Method: Same as above Dietary Protein Intake Compliance: Same as above	Muscle Strength - Handgrip strength Measure/Method of Assessment: Measured using handgrip dynamometer Muscle Strength- 5-time chair rise test Measure/Method of Assessment: NR Physical Performance - 6 min walking distance Measure/Method of Assessment: NR Physical Performance - 6 meter walking speed Measure/Method of Assessment: Usual pace Muscle Mass - Lean body mass Measure/Method of Assessment: BIA (Inbody S10, Biospace device, USA) Muscle Mass - Relative Appendicular Skeletal Muscle mass Measure/Method: Appendicular muscle mass divided by squared height in meters.

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Medication use: Excluded those using anabolic hormones Supplement use: NR Pregnant or lactating: NR</p> <p>Comparator: Normal Protein N: 25 % Female: 44% Mean Age (SD): 54 (8.6) y Race/Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 25.6 (3.8) kg/m² Income level: NR Mean education level (SD): 15.5 (2.7) y Mean physical activity level (SD): 1954.0 (1646.4) kcal/wk Health status/ Comorbidities: Excluded: (1) history of fracture or severe arthritis in recent 6 months, (2) known history of chronic kidney disease stage III and over, i.e. estimated glomerular filtered rate (eGFR) < 60 ml/min/1.73 m², (3) contraindicated for magnetic resonance imaging, (4) using anabolic hormones in the past 3 months, (5) were disability or limited functional ability, (6) having advanced, active or uncontrolled diseases, and (6) dementia, cognitive impairment or other sensory impairment that limited communication and understanding of the study</p>	<p>Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Dietary Protein Intake Compliance (%): 79.5%</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eualoric</p> <p>Study duration: 12 weeks</p>		

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	Medication use: Excluded those using anabolic hormones Supplement use: NR Pregnant or lactating: NR			
PMID: 34609621 Reinders 2022⁶¹ Location/Country: Finland, Netherlands HDI: Very High Setting: Community Dwelling, Urban and Rural Study Design: RCT (Parallel) Funding Source: Government Risk of bias score: Low	Study of: Adults Total sample N: 187 Intervention: Protein advice N: 96 % Female: 52.1% Mean Age (SD): 75.9 (5.0) y Race/ Ethnicity: NR Menopausal Status: NR Obesity Status: NR Mean BMI (SD): 26.3 (2.9) kg/m ² Income level: NR Education level: Lower education: 5.2% Middle education: 18.8% Higher education: 76% Physical activity level: NR Health status/ Comorbidities: Self-perceived health: Very poor/poor: 0% Not poor/not good: 19.8% Good/ very good: 80.2% Medication use: NR Supplement use: NR Pregnant or lactating: NR Comparator: Control N: 91 % Female: 54.9% Mean Age (SD): 75.0 (4.4) y Race/ Ethnicity: NR Menopausal Status: NR Obesity Status: NR Mean BMI (SD): 26.9 (2.9) kg/m ²	Intervention: Protein advice Intended Protein Amount: ≥ 1.2 g/kg aBW/d Carbohydrate: NR Fat: NR Baseline Protein Amount Mean (SD): 60.4 (1.3) g/d; 0.82 (0.01) g/kg aBW/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Actual Protein Amount at the end of the study Mean (SD): 89.1 (2.3) g/d; 1.21 (0.03) g/kg aBW/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Dietary Protein Intake Compliance (%): <0.8 g/kg aBW/d – 4.4% 0.8–1.0 g/kg aBW/d – 14.4% 1.0–1.2 g/kg aBW/d – 32.2% ≥ 1.2 g/kg aBW/d – 48.9% Protein type/source: Mixed Energy balance status: Eucaloric Comparator: Control Intended Protein Amount: NR Carbohydrate: NR	Intervention: Protein advice How protein was administered: Participants received personalized dietary advice by nutritionist to increase protein intake to ≥ 1.2 g/kg aBW/d using regular protein-rich foods purchased by the respondents and protein enriched food products freely provided by the research team Protein Assessment Method: Assessed prior to each clinic visit through a full dietary assessment using food diaries on three days, followed by a 24h dietary recall to assess habitual protein intake. Protein intake assessed at 3 months and 6 months. Dietary Protein Intake Compliance: Compliance of study participants to adhere to the advice to increase protein intake was indicated by the percentage of participants reaching a certain protein intake (<0.8 g/kg aBW/d, 0.8–1.0 g/kg aBW/d, 1.0–1.2 g/kg aBW/d or ≥ 1.2 g/kg aBW/d) for each	Physical Performance - 400 m walk speed Measure/Method of Assessment: After 40-m warmup, participants were instructed to walk as fast as possible at a pace they could maintain for 400 m Physical Performance - SPPB Measure/Method of Assessment: The SPPB consists of three components: balance, gait speed and chair rise ability Muscle Strength - Handgrip strength Measure/Method of Assessment: Measured using handgrip dynamometer Muscle Strength - Leg extension strength Measure/Method of Assessment: NR Muscle Mass - Fat Free Mass

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Income level: NR Education level: Lower education: 5.5% Middle education: 24.2% Higher education: 70.3% Physical activity level: NR Health status/ Comorbidities: Self-perceived health: Very poor/poor: 0% Not poor/not good: 19.8% Good/ very good: 80.3% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 60.5 (1.2) g/d; 0.82 (0.01) g/kg aBW/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study Mean (SD): 63.7 g/d; 0.86 (0.02) g/kg aBW/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Dietary Protein Intake Compliance (%): <0.8 g/kg aBW/d – 40.5% 0.8–1.0 g/kg aBW/d – 36.9% 1.0–1.2 g/kg aBW/d – 15.5% ≥1.2 g/kg aBW/d – 7.1%</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 6 months</p>	<p>study group at each clinic visit.</p> <p>Comparator: Control</p> <p>How protein was administered: Did not receive any protein advice or protein enriched foods</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	<p>Measure/Method of Assessment: BIA (BodyStat 1500MDD, Bodystat Ltd, Douglas, Isle of Men, United Kingdom)</p>
<p>PMID: 29687650 Smith 2018⁶² Location/Country: USA HDI: Very high Setting: Community dwelling Urban/Rural: NR Study design: RCT (parallel) Funding source: Nonprofit, government Risk of bias score: Low</p>	<p>Study of: Adults Total sample N: 52</p> <p>Intervention: Weight loss plus whey protein N: 25 % Female: 100% Mean Age (SD): NR Race/ Ethnicity: NR Menopausal Status: Postmenopausal Obesity Status: 100% Obese Mean BMI (SD): NR</p>	<p>Intervention: Weight loss plus whey protein</p> <p>Intended Protein Amount: 1.2 g/kg/d Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p>	<p>Intervention: Weight loss plus whey protein</p> <p>How protein was administered: Two nutrition bars per day for breakfast and frozen entrees for lunch and dinner were provided to the participants. Individuals also received two servings of whey protein isolate per day with breakfast and as a midafternoon snack.</p>	<p>Muscle Mass - Total fat-free mass</p> <p>Measure/Method of Assessment: DXA (Lunar iDA; GE Healthcare Lunar; Madison, Wisconsin)</p> <p>Muscle Mass - Total body lean mass</p> <p>Measure/Method of Assessment: DXA (Lunar</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Income level: NR Education level: NR Physical activity level: Excluded if engaged in ≥ 1.5 hours of exercise/week Health status/ Comorbidities: Excluded if they had serious chronic disease (e.g. neuromuscular, cardiopulmonary, chronic kidney disease, diabetes, cancer) or a condition that could interfere with body composition imaging (e.g., certain metal implants) Medication use: Excluded those that were taking medications that could affect muscle mass and/or function (e.g., HMG-CoA reductase inhibitors, steroids) within 1 year before enrolling in the study. Supplement use: NR Pregnant or lactating: NR</p> <p>Comparator: Weight loss plus recommended protein N: 27 % Female: 100% Mean Age (SD): NR Race/ Ethnicity: NR Menopausal Status: Postmenopausal Obesity Status: 100% Obese Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: Excluded if engaged in ≥ 1.5 hours of exercise/week</p>	<p>Actual Protein Amount at the end of the study Mean (SD): 31 (1) % of energy; 105 (2) g/d; 1.22 (0.03) g/kg/d Carbohydrate Mean (SD): 44 (1) % of energy Fat Mean (SD): 24 (1) % of energy</p> <p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Comparator: Weight loss plus recommended protein</p> <p>Intended Protein Amount: 0.8 g/kg/d Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study Mean (SD): 22 (1) % of energy; 74 (3) g/d; 0.86 (0.03) g/kg/d Carbohydrate Mean (SD): 50 (1) % of energy Fat Mean (SD): 28 (1) % of energy</p>	<p>Protein Assessment Method: Dietary intake was monitored by reviewing subjects' daily diet records during weekly visits with the study dietician.</p> <p>Dietary Protein Intake Compliance: Dietary compliance: (1) all meals and the protein supplement were provided to the study subjects, (2) dietary intake was monitored by reviewing subjects' daily diet records during weekly visits with the study dietician, and (3) blood urea nitrogen and, in a subset of participants, urinary urea nitrogen excretion were measured as objective markers of protein intake.</p> <p>Comparator: Weight loss plus recommended protein N: 27</p> <p>How protein was administered: Two nutrition bars per day for breakfast and frozen entrees for lunch and dinner were provided to the participants. Individuals also received isocaloric foods compared to the whey protein isolate in the increased protein group that provided mostly carbohydrates and fat per day with breakfast and as a midafternoon snack.</p>	<p>iDA; GE Healthcare Lunar; Madison, Wisconsin)</p> <p>Muscle Strength - Sum 1-RM strength</p> <p>Measure/Method of Assessment: The maximal amount of weight each participant was able to lift just once, evaluated with a Hoist multi-station weight machine</p> <p>Muscle Strength - Sum knee extension peak torque</p> <p>Measure/Method of Assessment: Peak isometric and isokinetic (608/s & 1808/s) torque of the knee extensors and flexors of the dominant leg were evaluated using Biodex 3 dynamometer. Exercise repeated 3x, the mean of the 2 highest torque recordings for each exercise used in analysis.</p> <p>Muscle Strength - Sum knee flexion peak torque</p> <p>Measure/Method of Assessment: Peak isometric and isokinetic (608/s & 1808/s) torque of the knee extensors and flexors of the dominant leg were evaluated using Biodex 3 dynamometer. Exercise repeated 3x, the mean of the 2 highest torque recordings</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Health status/ Comorbidities: Excluded if they had serious chronic disease (e.g. neuromuscular, cardiopulmonary, chronic kidney disease, diabetes, cancer) or a condition that could interfere with body composition imaging (e.g., certain metal implants)</p> <p>Medication use: Excluded those that were taking medications that could affect muscle mass and/or function (e.g., HMG-CoA reductase inhibitors, steroids) within 1 year before enrolling in the study.</p> <p>Supplement use: NR</p> <p>Pregnant or lactating: NR</p>	<p>Dietary Protein Intake Compliance (%): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Study duration: About 6 months (when participant lost 10% of body weight)</p>	<p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	<p>for each exercise used in analysis.</p>
<p>PMID: 28492492</p> <p>Stojkovic 2017⁶³</p> <p>Location/Country: USA</p> <p>HDI: Very high</p> <p>Setting: Community dwelling</p> <p>Urban/Rural: NR</p> <p>Study design: Ancillary study of an RCT (parallel)</p> <p>Funding Source: Academic, government</p> <p>Risk of bias score: High</p>	<p>Study of: Adults</p> <p>Total sample N: 84</p> <p>Intervention: Protein Group</p> <p>N: 38</p> <p>% Female: 100%</p> <p>Mean Age (SD): 68.9 (0.9) y</p> <p>Race/ Ethnicity: NR</p> <p>Menopausal Status: Postmenopausal</p> <p>Obesity Status: NR</p> <p>Mean BMI (SD): 26 (0.6) kg/m²</p> <p>Income level: NR</p> <p>Education level: NR</p> <p>Mean physical activity level (SD): NR</p> <p>Health status/ Comorbidities: NR</p> <p>Medication use: NR</p> <p>Supplement use: NR</p>	<p>Intervention: Protein Group</p> <p>Intended Protein Amount: NR</p> <p>Carbohydrate: NR</p> <p>Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 73.5 (2.7) g/d</p> <p>Carbohydrate Mean (SD): 207.2 (9.0) g/d</p> <p>Fat Mean (SD): 56.1 (2.7) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 98.5 (2.8) g/d (total protein)</p> <p>Carbohydrate Mean (SD): 198.9 (8.9) g/d</p> <p>Fat Mean (SD): 51.6 (2.5) g/d</p>	<p>Intervention: Protein Group</p> <p>How protein was administered: Subjects consumed a minimum of 20 g of protein supplement for 18 months</p> <p>Protein Assessment Method: Participants completed a 3-day food record prior to each study visit. Food records were analyzed using the ESHA Food Processor software program (ESHA Research, Salem, OR, USA, version 10.1.0)</p>	<p>Muscle Mass - Body lean mass</p> <p>Measure/Method of Assessment: DXA, using either a Hologic 4500 W machine (Yale University School of Medicine) or a Lunar Prodigy DPX-IQ (University of Connecticut Health Center)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	Pregnant or lactating: NR Comparator: Carbohydrate Group N: 46 % Female: 100% Mean Age (SD): 69.3 (0.09) y Race/ Ethnicity: NR Menopausal Status: Postmenopausal Obesity Status: NR Mean BMI (SD): 25.8 (0.6) kg/m ² Income level: NR Education level: NR Mean physical activity level (SD): NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR	Dietary Protein Intake Compliance (%): NR Protein type/source: Animal; whey protein Energy balance status: Eucaloric Comparator: Carbohydrate Group Intended Protein Amount: NR Carbohydrate: NR Fat: NR Baseline Protein Amount Mean (SD): 71.5 (2.2) g/d Carbohydrate Mean (SD): 201.2 (6.9) g/d Fat Mean (SD): 62.5 (3.9) g/d Actual Protein Amount at the end of the study Mean (SD): 69.8 (2.5) g/d Carbohydrate Mean (SD): 232.3 (8.7) g/d (total) Fat Mean (SD): 57.1 (2.8) g/d Dietary Protein Intake Compliance (%): NR Protein type/source: Mixed Energy balance status: Eucaloric Study duration: 18 months	Dietary Protein Intake Compliance: Supplement adherence and diet were carefully monitored by dietitians. Comparator: Carbohydrate Group How protein was administered: Received an isocaloric maltodextrin control supplement Protein Assessment Method: Same as above Dietary Protein Intake Compliance: Same as above	
PMID: 22406907 Wycherley 2012 ^{*38}	Study of: Adults Total sample N: 68	Intervention: High Protein	Intervention: High Protein How protein was	Muscle Mass - Total body fat free mass

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>Location/Country: Australia HDI: Very high Setting: Community dwelling Urban/Rural: NR Study design: RCT (parallel) Funding source: Industry Risk of bias score: Moderate</p>	<p>Intervention: High Protein N: 33 % Female: 0% Mean Age (SD): 51.3 (9.4) y Race/Ethnicity: NR Menopausal status: NA Obesity status: 100% overweight or obese Mean BMI (SD): 33.0 (3.9) kg/m² (total study population mean) Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: Excluded: diabetes, uncontrolled hypertension; history of GI, renal, coronary, metabolic, or hepatic disease or malignancy Medication use: Excluded those taking hypoglycemic medication or drugs which affect insulin sensitivity Supplement use: NR Pregnant or lactating: NA</p> <p>Comparator: Low Protein N: 35 % Female: 0% Mean Age (SD): 50.2 (9.3) y Race/Ethnicity: NR Menopausal status: NA Obesity status: 100% overweight or obese Mean BMI (SD): 33.0 (3.9) kg/m² (total study population mean) Income level: NR Education level: NR Physical activity level: NR</p>	<p>Intended Protein Amount: 35% of energy; 142 g/d; ~1.30 g/kg/d Carbohydrate: 40% of energy; 135 g/d Fat: 25% of energy (total 53 g/d, saturated 14 g/d)</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study: Mean (SD): 0-12 weeks: 131.1 (15.4) g/d; 32.5 (3.3) % of energy 12-52 weeks: 132 (13.9) g/d; 30.7 (3.1) % of energy Carbohydrate Mean (SD): 0-12 weeks: 154.4 (31.8) g/d; 37.4 (3.8) % of energy 12-52 weeks: 157.9 (28.1) g/d; 35.9 (3.4) % of energy Fat Mean (SD): 0-12 weeks: 50.6 (6.5) g/d; 27.3 (3.0) % of energy 12-52 weeks: 60.0 (12.6) g/d; 29.8 (3.6) % of energy</p> <p>Dietary Protein Intake Compliance (%): NR – good compliance rate stated</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Comparator: Low Protein</p>	<p>administered: Participants met with dietitian and received detailed dietary prescription, meal planning advice, and recipe information every 2 weeks for the first 12 weeks. They were supplied with a 2-week provision of diet-specific key foods (60% of energy intake) for the first 12 weeks. Participants met with dietician monthly and received detailed dietary prescription, meal planning advice, and recipe information for remainder of study duration.</p> <p>Protein Assessment Method: Participants kept a daily semi-quantitative food record. Dietary intake was assessed using a computerized database (Foodworks Professional Edition, version 4, 1998; Xyris Software, Highgate Hill, Australia) based on the analysis of 3 non-consecutive days (1 weekend day and 2 weekdays) of each 2-week period. The intake was calculated as an average of the 2-week diet record data blocks for 0-12 weeks and 12-52 weeks.</p> <p>Dietary Protein Intake Compliance: Food checklist</p>	<p>Measure/Method of Assessment: DXA (Lunar Prodigy; General Electric, Madison, WI, USA)</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>Health status/ Comorbidities: Excluded: diabetes, uncontrolled hypertension; history of GI, renal, coronary, metabolic, or hepatic disease or malignancy Medication use: Excluded those taking hypoglycemic medication or drugs which affect insulin sensitivity Supplement use: NR Pregnant or lactating: NA</p>	<p>Intended Protein Amount: 17% of energy; 88 g/d; ~0.85 g/kg/d Carbohydrate: 58% of energy; 198 g/d Fat: 25% of energy (total 51 g/d, saturated 14 g/d)</p> <p>Baseline Protein Amount Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Actual Protein Amount at the end of the study Mean (SD): 0-12 weeks: 82.7 (6.7) g/d; 20.5 (1.4) % of energy 12-52 weeks: 83.3 (10.3) g/d; 20.4 (1.0) % of energy Carbohydrate Mean (SD): 0-12 weeks: 208.4 (16.3) g/d; 51.0 (3.6) % of energy 12-52 weeks: 195.2 (23.4) g/d; 47.3 (3.9) % of energy Fat Mean (SD): 0-12 weeks: 46.7 (7.5) g/d; 25.0 (3.3) % of energy 12-52 weeks: 52.2 (8.7) g/d; 27.7 (3.2) % of energy</p> <p>Dietary Protein Intake Compliance (%): NR – good compliance rate stated</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Hypocaloric</p> <p>Study duration: 52 weeks</p>	<p>Comparator: Low Protein</p> <p>How protein was administered: Participants met with dietitian and received detailed dietary prescription, meal planning advice, and recipe information every 2 weeks for the first 12 weeks. They were supplied with a 2-week provision of diet-specific key foods (60% of energy intake) for the first 12 weeks. Participants met with dietician monthly and received detailed dietary prescription, meal planning advice, and recipe information for remainder of study duration.</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
<p>PMID: 26400966 Zhu 2015⁶⁴ Location/Country: Australia HDI: Very high Setting: Community dwelling Urban/Rural: Metropolitan Study design: RCT (parallel) Funding source: Academic, government Risk of bias score: Low</p>	<p>Study of: Adults Total sample N: 196</p> <p>Intervention: High Protein N: 101 % Female: 100% Mean Age (SD): 74.2 (2.8) y Race/ Ethnicity: NR Menopausal Status: Postmenopausal Obesity Status: NR Mean BMI (SD): 26.1 (3.8) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 453 (390) MET -min/wk Health status/ Comorbidities: Excluded those with a previous osteoporotic fracture or metabolic bone disease, or any other condition that may affect the participation of the study Medication use: Excluded those taking medication for osteoporosis (including hormone replacement therapy) apart from calcium or vitamin D either currently or within the last year, or were taking steroid tablets in the previous 3 months or had taken >7 g in total in their lifetime Supplement use: Excluded those with a high protein intake (>1.5 g/kg/d) Pregnant or lactating: NR</p> <p>Comparator: Placebo supplement</p>	<p>Intervention: High Protein</p> <p>Intended Protein Amount: Supplement with 30 g of protein Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount Mean (SD): 76 (18) g/d; 1.2 (0.3) g/kg/d Carbohydrate Mean (SD): 190 (45) g/d Fat Mean (SD): 63 (19) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 95.9 (19.9) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Dietary Protein Intake Compliance (%): 87.1%</p> <p>Protein type/source: Animal: whey protein isolate supplement</p> <p>Energy balance status: Eucaloric</p> <p>Comparator: Placebo supplement</p> <p>Intended Protein Amount: Supplement with 2.1 g of protein Carbohydrate: NR Fat: NR</p> <p>Baseline Protein Amount</p>	<p>Intervention: High Protein</p> <p>How protein was administered: Daily whey supplement protein shake before breakfast (30 g of protein)</p> <p>Protein Assessment Method: 3 day weighed food record (2 weekdays and 1 weekend day) analyzed with AUSNUT99 database (Foodworks Professional edition version 3.02) by nutritionists trained in dietary assessment.</p> <p>Dietary Protein Intake Compliance: Urinary nitrogen excretion was a compliance measure. Empty test containers returned by the participants.</p> <p>Comparator: Placebo supplement</p> <p>How protein was administered: Daily placebo supplement shake before breakfast (2.1 g of protein)</p> <p>Protein Assessment Method: Same as above</p> <p>Dietary Protein Intake Compliance: Same as above</p>	<p>Muscle Mass – Appendicular lean mass/ skeletal muscle mass</p> <p>Measure/Method of Assessment: DXA (Hologic Discovery A fan-beam densitometer)</p> <p>Muscle Mass - Adjusted appendicular lean mass/ skeletal muscle mass</p> <p>Measure/Method of Assessment: Appendicular skeletal muscle mass divided by height squared</p> <p>Muscle Strength - Handgrip strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p> <p>Muscle Strength - Knee flexion</p> <p>Measure/Method of Assessment: Maximal muscle contraction against a strain gauge with the best of 3 attempts recorded.</p> <p>Muscle Strength - Knee extension</p> <p>Measure/Method of Assessment: Maximal muscle contraction against a strain gauge with the best of 3 attempts recorded.</p>

Study	Participants	Intervention(s) (Content)	Intervention(s) (Methods of administration and assessment)	Outcome (Measures and methods of assessment)
	<p>N: 95 % Female: 100% Mean Age (SD): 74.3 (2.6) y Race/ Ethnicity: NR Menopausal Status: Postmenopausal Obesity Status: NR Mean BMI (SD): 27.2 (4.0) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 398 (376) MET- min/wk Health status/ Comorbidities: Excluded those with a previous osteoporotic fracture or metabolic bone disease, or any other condition that may affect the participation of the study Medication use: Excluded those taking medication for osteoporosis (including hormone replacement therapy) apart from calcium or vitamin D either currently or within the last year, or were taking steroid tablets in the previous 3 months or had taken >7 g in total in their lifetime Supplement use: Excluded those with a high protein intake (>1.5 g/kg/d) Pregnant or lactating: NR</p>	<p>Mean (SD): 76 (16) g/day; 1.1 (0.3) g/kg/d Carbohydrate Mean (SD): 190 (42) g/d Fat Mean (SD): 61 (20) g/d</p> <p>Actual Protein Amount at the end of the study Mean (SD): 73.1 (16.9) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Dietary Protein Intake Compliance (%): 80.8%</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 2 y</p>		<p>Physical Performance - TUG</p> <p>Measure/Method of Assessment: Timed while getting up, walking 3 meters, turning, returning to the chair, and sitting down again</p>

Abbreviations: aBW = adjusted body weight; BIA = bioelectrical impedance analysis; BMI = body mass index; COPD = chronic obstructive pulmonary disease; cpm = counts per minute d = days; DXA = Dual-energy x-ray absorptiometry; FFQ = Food frequency questionnaire; g = gram; h = hour; HDI = human development index; kg = kilograms; kg/m² = kilograms per meters squared; LC n-3 PUFA = long chain n-3 polyunsaturated fatty acids; m = meters; METs = metabolic equivalents; min = minutes; ml = milliliters; mg = milligrams; NA = not applicable; NR = not reported; nmol/L = nanomoles per liter; NR = not reported PMID = PubMed Identification Number; PUFA = polyunsaturated fatty acids; RCT = randomized controlled trial; RM: Rep maximum; RoB = Risk of Bias; SD = standard deviation; SE = standard error; SEM = standard error of the mean; SPPB = Short Physical Performance Battery; TUG = Timed-Up-and-Go; wk = week; w/o = without; WI = wisconsin; y = year

Note: *Studies overlap KQs

Table C6. Evidence table for Sarcopenia Non-Randomized Controlled Trials

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
<p>PMID: 24219187 Beasley 2013⁶⁵ Location/Country: USA HDI: Very high Setting: NR Urban/Rural: NR Study design: Prospective cohort study Funding source: Nonprofit, government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 134,961</p> <p>Quintile 1: 6.6-13.1% of energy N: 26,994 % Female: 100% Mean Age (SD): 66.0 (7.2) y Race/ Ethnicity: White: 78.1% Black: 14.1% Hispanic: 3.70% American Indian: 0.54% Asian/Pacific Islander: 2.32% Other: 1.27% Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 29.2 (7.0) kg/m² Income level: < \$20,000: 25.5% \$20,000-\$49,999: 48.7% \$50,000-\$74,999: 15.1% ≥ \$75,000: 10.8% Education level: ≤ High school diploma or GED: 28.4% Some college: 40.5% ≥ College degree: 31.1% Mean physical activity level (SD): 9.9 (12) MET-hr/wk Health Status/ Comorbidities: Arthritis: 53.0% Diabetes: 4.05% Cancer: 10.4% Hypertension: 39.4% Emphysema: 5.40%</p>	<p>Quintile 1: 6.6-13.1% of energy</p> <p>Baseline Protein Amount Mean (SD): 71.5 (12.1) g/d; 0.97 (0.17) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 2: 13.1-13.8% of energy</p> <p>Baseline Protein Amount Mean (SD): 74.7 (11.0) g/d; 1.03 (0.17) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 3: 13.9-14.6% of energy</p> <p>Baseline Protein Amount</p>	<p>Protein Assessment Method: At baseline protein amount was derived from self-administered 122-item WHI FFQ. The WHI Nutritional Biomarkers Study was conducted to evaluate accuracy of self-reported protein consumption.</p>	<p>Muscle Strength - Grip strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p> <p>Muscle Strength - Chair stand test</p> <p>Measure/Method of Assessment: Two 15-second trials of repeated chair stands with arms folded across the chest were conducted, with a 1–2-minute rest between trials.</p> <p>Physical Performance - 6-m timed walk</p> <p>Measure/Method of Assessment: Duration of the walk was measured at usual pace</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Hip fracture: 1.05% Medication use: Unopposed estrogen use: 20.2 % Estrogen + progesterone use: 11.4% Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 2: 13.1-13.8% of energy N: 26,991 % Female: 100% Mean Age (SD): 64.9 (7.0) y Race/ Ethnicity: White: 83.4% Black: 9.04% Hispanic: 3.29% American Indian: 0.46% Asian/Pacific Islander: 2.66% Other: 1.15% Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 28.6 (6.1) kg/m² Income level: < \$20,000: 18.2% \$20,000-\$49,999: 48.5% \$50,000 - \$74,999: 18.4% ≥ \$75,000: 14.9% Education level: ≤ High school diploma or GED: 23.7% Some college: 38.8% ≥ College degree: 37.5 % Mean physical activity level (SD): 11.5 (13.1) MET-hr/wk Health Status/ Comorbidities: Arthritis: 49.9% Diabetes: 4.30% Cancer: 9.81%</p>	<p>Mean (SD): 76.7 (10.5) g/d; 1.07 (0.17) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 4: 14.7-15.4% of energy</p> <p>Baseline Protein Amount Mean (SD): 79.0 (10.1) g/d; 1.12 (0.18) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 5: 15.4-22.3% of energy</p> <p>Baseline Protein Amount Mean (SD): 81.7 (9.9) g/d; 1.19 (0.20) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Hypertension: 36.7% Emphysema: 3.83% Hip fracture: 1.02% Medication use: Unopposed estrogen use: 22.6% Estrogen + progesterone use: 15.3% Supplement use: NR Pregnant or lactating women: NR</p> <p>Quintile 3: 13.9-14.6% of energy N: 26,992 % Female: 100% Mean Age (SD): 63.6 (6.9) y Race/ Ethnicity: White: 85.4% Black: 7.28% Hispanic: 3.18% American Indian: 0.34% Asian/Pacific Islander: 2.71% Other: 1.11% Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 28.0 (5.7) kg/m² Income level: < \$20,000: 15.0% \$20,000-\$49,999: 46.3% \$50,000 - \$74,999: 20.4% ≥ \$75,000: 18.2% Education level: ≤ High school diploma or GED: 21.2% Some college: 37.7% ≥ College degree: 41.2% Mean physical activity level (SD): 12.5 (13.6) MET-hr/wk Health Status/ Comorbidities:</p>	<p>Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein type/ source: Mixed Energy balance: Eucaloric Study duration: 11.5 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Arthritis: 48.5% Diabetes: 4.45% Cancer: 9.34% Hypertension: 34.3% Emphysema: 3.47% Hip fracture: 0.91% Medication use: Unopposed estrogen use: 23.7% Estrogen + progesterone use: 18.2% Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 4: 14.7-15.4% of energy N: 26,992 % Female: 100% Mean Age (SD): 61.9 (6.7) y Race/ Ethnicity: White: 86.5% Black: 6.09% Hispanic: 3.63% American Indian: 0.31%, Asian/Pacific Islander: 2.54% Other: 0.96% Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 27.5 (5.4) kg/m² Income level: < \$20,000: 12.0% \$20,000-\$49,999: 43.1% \$50,000- \$74,999: 22.6% ≥ \$75,000: 22.3% Education level: ≤ High school diploma or GED: 18.6% Some college: 36.7% ≥ College degree: 44.8%</p>			

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Mean physical activity level (SD): 13.4 (13.7) MET-hr/wk Health Status/ Comorbidities: Arthritis: 46.0% Diabetes: 4.42% Cancer: 8.84% Hypertension: 31.2% Emphysema: 2.96% Hip fracture: 0.86% Medication use: Unopposed estrogen use: 24.5% Estrogen + progesterone use: 21.0% Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 5: 15.4-22.3% of energy N: 26,992 % Female: 100% Mean Age (SD): 59.5 ± 6.3 y Race/ Ethnicity: White: 85.6% Black: 5.90% Hispanic: 3.86% American Indian: 0.41% Asian/Pacific Islander: 3.15% Other: 1.08% Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 26.6 (4.9) kg/m² Income level: < \$20,000: 9.40% \$20,000-\$49,999: 37.7% \$50,000 -\$74,999: 24.1% ≥ \$75,000: 28.9% Education level: ≤ High school diploma or GED: 15.6%</p>			

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	Some college: 36.0% ≥ College degree: 48.5% Mean physical activity level (SD): 14.9 (14.8) MET-hr/wk Health Status/ Comorbidities: Arthritis: 40.6% Diabetes: 4.46% Cancer: 8.95% Hypertension: 27.1% Emphysema: 2.76% Hip fracture: 0.57% Medication use: Unopposed estrogen use: 24.4% Estrogen + progesterone use: 24.5% Supplement use: NR Pregnant or lactating: NR			
PMID: 24522470 Chan 2014 ⁶⁶ Location/Country: Hong Kong/ China HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: Prospective cohort study Funding source: Academic, nonprofit Risk of bias score: High	Study of: Adults Total sample N: 2,726 Quartile 1: ≤0.9 g of protein/kg/d N: 617 % Female: 62.1% Age Range: ≤69 y: 37.9% 70-74 y: 35.8% 75+ y: 26.3% Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR BMI: <18.5 kg/m ² : 1.6% 18.5-<23 kg/m ² : 25.9% 23-24.9 kg/m ² : 24.8% 25-29.9 kg/m ² : 41.3% ≥30 kg/m ² : 6.3% Income level: NR Education level:	Quartile 1: ≤0.9 g of protein/kg/d Baseline Protein Amount Mean (SD): Animal protein:0.35 (0.11) g/kg/d Plant protein: 0.37 (0.10) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Quartile 2: 0.91-1.2 g of protein/kg/d Baseline Protein Amount	Protein Assessment Method: At baseline, dietary intake was measured with a validated semi-quantitative FFQ. Using food tables from the Chinese Medical Sciences Institute and McCance and Widdowson, the mean daily quantitation of nutrients was determined. The quantity of animal and vegetable proteins consumed was calculated in addition to the overall protein intake.	Physical Performance - 6-m timed walk Measure/Method of Assessment: Duration of the walk was measured as well as the number of steps. Physical Performance- 20 cm narrow walk Measure/Method of Assessment: Participants walked the 6-m course within a 20-cm narrow path and performance was scored for time. Muscle Mass – Appendicular lean mass/ skeletal muscle mass Measure/Method of Assessment: DXA (Hologic)

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Primary or below: 80.9% Secondary/matriculation: 12.8% University or above: 6.3% Mean physical activity level (SD): 90.2 (38.5) PASE score Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 2: 0.91-1.2 g of protein/kg/d N: 677 % Female: 52.7% Age Range: ≤ 69 y: 37.2% 70-74 y: 35.5% 75+ y: 27.3% Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR BMI: <18.5 kg/m²: 3.1% 18.5-<23 kg/m²: 33.7% 23-24.9 kg/m²: 26.9% 25-29.9 kg/m²: 34.3% ≥30 kg/m²: 2.1% Income level: NR Education level: Primary or below: 71.3% Secondary/matriculation: 19.8%, University or above: 8.9% Mean physical activity level (SD): 94.5 (44.9) PASE score Health status/ Comorbidities: NR Medication use: NR Supplement use: NR</p>	<p>Mean (SD): Animal protein: 0.56 (0.15) g/kg/d Plant protein: 0.50 (0.14) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 3: 1.21-1.6 g of protein/kg/day</p> <p>Baseline Protein Amount Mean (SD): Animal protein: 0.77 (0.20) g/kg/d Plant protein: 0.63 (0.19) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 4: ≥1.61 g of protein/kg/day</p> <p>Baseline Protein Amount Mean (SD):</p>		<p>QDR-4500W, software version 11.2; hologic, Inc., Waltham, Ma, USA)</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Pregnant or lactating: NR</p> <p>Quartile 3: 1.21-1.6 g of protein/kg/day N: 705 % Female: 44.1% Age Range: ≤69 y: 39.0% 70-74 y: 38.0% 75+ y: 23.0% Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR BMI: <18.5 kg/m²: 4.3% 18.5-<23 kg/m²: 42.0% 23-24.9 kg/m²: 27.7% 25-29.9 kg/m²: 23.8% ≥30 kg/m²: 2.3% Income level: NR Education level: Primary or below: 65% Secondary/matriculation: 21.8% University or above: 13.2% Mean physical activity level (SD): 95.7 (44.2) PASE score Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 4: ≥1.61 g of protein/kg/day N: 727 % Female: 36.3% Age Range: ≤69 y: 40.7% 70-74 y: 35.1% 75+ y: 24.2%</p>	<p>Animal protein: 1.21 (0.48) g/kg/d Plant protein: 0.89 (0.36) g/kg/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance: Eucaloric</p> <p>Study duration: 4 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR BMI: <18.5 kg/m ² : 8.1% 18.5-<23 kg/m ² : 47.9% 23-24.9 kg/m ² : 21.5% 25-29.9 kg/m ² : 21.2% ≥30 kg/m ² : 1.4% Income level: NR Education level: Primary or below: 60.9% Secondary/matriculation: 24.2% University or above: 14.9% Mean physical activity level (SD): 103.1(47.6) PASE score Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR			
PMID: 37922694 Chen 2023 ⁶⁷ Location/Country: China HDI: Very high Setting: Community dwelling Urban/Rural: NR Study design: Prospective cohort study Funding source: Other Risk of bias score: High	Study of: Adults Total sample N: 2709 Arm 1: Men N: 855 % Female: 0% Mean Age (SD): 60.4 (6.4) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 23.9 (2.8) kg/m ² Income level: NR Education level: High school or below 65% College or above: 35% Mean physical activity level (SD): 34.9 (6.4) METs h/d Health status/ Comorbidities:	Arm 1: Men Baseline Protein Amount Mean (SD): 1.29 (0.24) g/d/kg Carbohydrate Mean (SD): 279.4 (49.9) g/d Fat Mean (SD): 53.5 (16.0) g/d Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Arm 2: Women	Protein Assessment Method: The dietary intake was assessed using a validated 79-item semi-quantitative, interviewer-administered, and paper-based food frequency questionnaire at baseline.	Muscle Mass – Appendicular lean mass/ skeletal muscle mass Measure/Method of Assessment: DXA (Hologic Inc. Discovery W, USA) Muscle Mass – ASMI Measure/Method of Assessment: Appendicular muscle mass divided by squared height in meters Muscle Strength – Handgrip strength

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	<p>Type 2 diabetes: 9.8% Dyslipidemia: 20.5% Medication use: NR Supplement use: 13.5% Pregnant or lactating: NA</p> <p>Arm 2: Women N: 1854 % Female: 100% Mean Age (SD): 57.5 (5.5) y Race/ Ethnicity: NR Menopausal status: 96.5% Obesity status: NR Mean BMI (SD): 23.3 (3.1) kg/m² Income level: NR Education level: High school or below 77.5% College or above: 22.5% Mean physical activity level (SD): 34.8 (5.6) METs h/d Health status/ Comorbidities: Type 2 diabetes: 6.9% Dyslipidemia: 22.2% Medication use: NR Supplement use: 22.5% Pregnant or lactating: NR</p>	<p>Baseline Protein Amount Mean (SD): 1.43 (0.28) g/d/kg Carbohydrate Mean (SD): 217.7 (40.1) g/d Fat Mean (SD): 48.5 (13.8) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 3.2 y</p>		<p>Measure/Method of Assessment: Hand dynamometer</p> <p>Muscle Strength – Chair stand test</p> <p>Measure/Method of Assessment: Recorded how long it took participants to stand up and sit down five times</p>
<p>PMID: 32520344 Elstgeest 2020⁶⁸ Location/Country: USA HDI: Very high Setting: Community dwelling Urban/Rural: Metropolitan Study design: Prospective cohort study Funding source: NR Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 3075</p> <p>Arm 1: Men N: 1163 % Female: 0% Mean Age (SD): 74.8 (2.9) y Menopausal status: NA Race/ Ethnicity: White: 68.8% Obesity status: NR Mean BMI (SD): 26.9 (3.8) kg/m² Income level: NR Education level:</p>	<p>Arm 1: Men</p> <p>Baseline Protein Amount Mean (SD): 71.3 (26.6) g/d; 0.94 (0.36) g/kg aBW/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p>	<p>Protein Assessment Method: At baseline, dietary intake was assessed using a 108-item modified version of the Block FFQ. Block Dietary Data Systems were used to determine nutrient intake.</p>	<p>Muscle Mass - Appendicular lean mass/ skeletal muscle mass</p> <p>Measure/Method of Assessment: DXA (Hologic 4500A, version 8.20a)</p> <p>Physical Performance- 20-m walk</p> <p>Measure/Method of Assessment: Participants were asked to walk a 20-m</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Less than high school: 22.5% High school graduation: 25.9% Postsecondary education: 51.6% Mean physical activity level (SD): Walking 165 (295) min/wk Health status/ Comorbidities: 0 diseases: 14.8% 1 disease: 27.4% ≥2 diseases: 57.8% Medication use: Oral steroid use: 2.1% Supplement use: NR Pregnant or lactating: NA</p> <p>Arm 2: Women N: 1237 % Female: 51.5% Mean Age (SD): 74.4 (2.8) y Menopausal status: Postmenopausal Race/ Ethnicity: White: 59.1% Obesity status: NR Mean BMI (SD): 27.4 (5.4) kg/m² Income level: NR Education level: Less than high school: 20.4% High school graduation: 39.1% Postsecondary education: 40.5% Mean physical activity level (SD): Walking 116 (228) min/wk Health status/ Comorbidities: 0 diseases: 11.2% 1 disease: 28.7% ≥2 diseases: 60.1% Medication use: Oral steroid use: 3.2%</p>	<p>Arm 2: Women</p> <p>Baseline Protein Amount Mean (SD): 60.7 (22.3) g/d; 0.95 (0.36) g/kg aBW/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 5 y</p>		<p>course at their usual walking pace.</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	Supplement use: NR Pregnant or lactating: NR			
PMID: 27465379 Farsijani 2016⁶⁹ Location/Country: Canada HDI: Very high Setting: Community dwelling Urban/Rural: Urban and suburban Study design: Prospective cohort study Funding source: Nonprofit, academic Risk of bias: High	Study of: Adults Total sample N: 1793 Quartile 1 (Men): Protein intake ≤ 62.12 g/d N: 88 % Female: 0% Mean Age (SD): 73.8 (4.1) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 27.1 (4.0) kg/m ² Income level: NR Mean education level (SD): 10.8 (5.5) y Physical activity level: NR Health status/ Comorbidities: Subjects free from cognitive impairment, COPD, class II heart failure and inflammatory digestive diseases, cancer Medication use: NR Supplement use: NR Pregnant or lactating: NA Quartile 2 (Men): Protein intake 62.13-71.62 g/d N: 87 % Female: 0% Mean Age (SD): 74.4 (4.4) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 28.5 (4.4) kg/m ² Income level: NR Mean education level (SD): 10.0 (4.6) y Physical activity level: NR	Quartile 1 (Men): Protein intake ≤ 62.12 g/d Baseline Protein Amount Mean (SD): 64.3 (14.3) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Quartile 2 (Men): Protein intake 62.13-71.62 g/d Baseline Protein Amount Mean (SD): 71.5 (16.0) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Quartile 3 (Men): Protein intake 71.63-80.66 g/d Baseline Protein Amount Mean (SD): 83.2 (17.3) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR	Protein Assessment Method: Protein intake was assessed using 24-h dietary recalls. A total of 6 nonconsecutive recalls were collected: 3 at baseline and 3 at the 2-y follow-up. Recalls were analyzed with the CANDAT nutrient analysis software	Muscle Mass - Lean mass Measure/ Method of Assessment: DXA (Lunar Prodigy; GE Medical) Muscle Mass - Appendicular lean mass/ skeletal muscle mass Measure/Method of Assessment: Calculated as the sum of nonbone LM of arms and legs.

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Health status/ Comorbidities: Subjects free from cognitive impairment, COPD, class II heart failure and inflammatory digestive diseases, cancer Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Quartile 3 (Men): Protein intake 71.63-80.66 g/d N: 88 % Female: 0% Mean Age (SD): 73.4 (4.3) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 28.3 (3.9) kg/m² Income level: NR Mean education level (SD): 10.1 (4.7) y Physical activity level: NR Health status/ Comorbidities: Subjects free from cognitive impairment, COPD, class II heart failure and inflammatory digestive diseases, cancer Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Quartile 4 (Men): Protein intake ≥80.67 g/d N: 88 % Female: 0% Mean Age (SD): 72.6 (3.8) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 28.5 (4.1) kg/m²</p>	<p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 4 (Men): Protein intake ≥80.67 g/d</p> <p>Baseline Protein Amount Mean (SD): 101.8 (21.3) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 1 (Women): Protein intake ≤64.81 g/d</p> <p>Baseline Protein Amount Mean (SD): 51.1 (12.5) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 2 (Women): Protein intake 64.82-73.46 g/d</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Income level: NR Mean education level (SD): 11.5 (4.7) y Physical activity level: NR Health status/ Comorbidities: NR Subjects free from cognitive impairment, COPD, class II heart failure and inflammatory digestive diseases, cancer Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Quartile 1 (Women): Protein intake \leq64.81 g/d N: 90 % Female: 100% Mean Age (SD): 73.6 (4.0) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.4 (4.3) kg/m²</p> <p>Income level: NR Mean education level (SD): 10.6 (3.4) y Physical activity level: NR Health status/ Comorbidities: NR Subjects free from cognitive impairment, COPD, class II heart failure and inflammatory digestive diseases, cancer Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 2 (Women): Protein intake 64.82-73.46 g/d N: 91 % Female: 100% Mean Age (SD): 74.6 (4.0) y Race/ Ethnicity: NR</p>	<p>Baseline Protein Amount Mean (SD): 62.6 (12.0) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 3 (Women): Protein intake 73.47-82.29 g/d</p> <p>Baseline Protein Amount Mean (SD): 69.8 (10.6) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 4 (Women): Protein intake \geq82.30 g/d</p> <p>Baseline Protein Amount Mean (SD): 86.7 (16.7) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Menopausal status: NR Obesity status: NR Mean BMI (SD): 28.1 (5.3) kg/m² Income level: NR Mean education level (SD): 10.6 (3.6) y Physical activity level: NR Health status/ Comorbidities: Subjects free from cognitive impairment, COPD, class II heart failure and inflammatory digestive diseases, cancer Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 3 (Women): Protein intake 73.47-82.29 g/d N: 90 % Female: 100% Mean Age (SD): 73.4 (3.9) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.7 (4.4) kg/m² Income level: NR Mean education level (SD): 10.5 (3.8) y Physical activity level: NR Health status/ Comorbidities: Subjects free from cognitive impairment, COPD, class II heart failure and inflammatory digestive diseases, cancer Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 4 (Women): Protein intake ≥82.30 g/d</p>	<p>Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 2 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	<p>N: 90 % Female: 100% Mean Age (SD): 72.8 (4.0) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 28.1 (4.9) kg/m² Income level: NR Mean education level (SD): 10.8 (3.9) year Physical activity level: NR Health status/ Comorbidities: Subjects free from cognitive impairment, COPD, class II heart failure and inflammatory digestive diseases, cancer Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>			
<p>PMID: 29191494 Granic 2017⁷⁰ Location/Country: UK HDI: Very high Setting: Community dwelling Urban/Rural: NR Study design: Prospective cohort study Funding source: Nonprofit, academic Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 722</p> <p>Arm 1: Low protein intake (<1 g of protein/kg aBW/d) N: 390 % Female: 66.9% Mean Age (SD): NR Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: 0-9 y: 68.0% 10-11 y: 21.4% ≥12 y: 10.6% Physical activity level: Low: 18.5 % Moderate: 47.7% High: 33.8 %</p>	<p>Arm 1: Low protein intake (<1 g of protein/kg aBW/d)</p> <p>Baseline Protein Intake: <1 g of protein/ kg aBW/d Carbohydrate: NR Fat: NR</p> <p>Protein Amount at the end of the study: NR Carbohydrate: NR Fat: NR</p> <p>Arm 2: Good protein intake (≥1 g of protein/kg aBW/d)</p> <p>Baseline Protein Intake: ≥1 g of protein/ kg aBW/d Carbohydrate: NR Fat: NR</p>	<p>Protein Assessment Method: At baseline, protein intake was estimated with a validated 24-hr multiple pass dietary recall (24-h MPR). A food code was assigned to each food and 2-day intakes were entered in a Microsoft Access based dietary data system. The codes were further grouped in 118 food groups based on McCance and Widdowson's composition of foods 6th edition.</p>	<p>Muscle Strength- Grip strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p> <p>Physical Performance - TUG</p> <p>Measure/Method of Assessment: Measures the time that takes to rise from a chair without using arms, walk 3 m at usual pace, turn, return to the chair, and sit down.</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Health status/ Co-morbidities: Mean multimorbidity (SD): 2.28 (1.21) Depressive symptoms: 0 to 5 (none): 78.1% 6 to 7 (mild): 13.5% >8 (severe): 8.2% Arthritis in hands: 6.7% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Arm 2: Good protein intake (≥1 g of protein/kg aBW/d) N: 390 % Female: 51.8% Mean Age (SD): NR Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: 0-9 y: 58.8% 10-11 y: 26.4% ≥12 y: 14.8% Physical activity level: Low: 16.3% Moderate: 42.3% High: 41.4% Health status/ Comorbidities: Mean multimorbidity (SD): 2.19 (1.25) Depressive symptoms: 0 to 5 (none): 83.2% 6 to 7 (mild): 10.9% >8 (severe): 5.9% Arthritis in hands: 6.4% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Protein Amount at the end of the study: NR Carbohydrate: NR Fat: NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 5 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
<p>PMID: 33515002 Hengeveld 2021⁷¹ Location/Country: Canada HDI: Very high Setting: Community dwelling Urban/Rural: Urban Study design: Prospective cohort study Funding source: NR Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 1754</p> <p>Arm 1: Men N: 524 % Female: 0% Mean Age (SD): 74.8 (4.0) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 28.1 (4.0) kg/m² Income level: NR Mean education level (SD): 12.0 (5.1) y Mean physical activity level (SD): 118 (55) PASE score Health status/ Comorbidities: Chronic diseases 0: 10.3% 1-2: 33.8% ≥3: 55.9% Medication use: 0: 10.7% 1-4: 49.8% ≥5: 39.5% Supplement use: NR Pregnant or lactating: NA</p> <p>Arm 2: Women N: 574 % Female: 32.72% Mean Age (SD): 75.2 (4.2) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.4 (4.7) kg/m² Income level: NR Mean education level (SD): 11.6 (3.9) y</p>	<p>Arm 1: Men</p> <p>Baseline Protein Amount Mean (SD): 82.7 (19.4) g/d; 1.06 (0.28) g/kg/d; 1.13 (0.27) g/kg aBW/d; 16.1 (2.5) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 2: Women</p> <p>Baseline Protein Intake Mean (SD): 68.3 (15.0) g/d; 1.07 (0.30) g/ kg BW/d; 1.12 (.26) g/kg aBW/d; 16.6 (2.5) of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 3 y</p>	<p>Protein Assessment Method: 3 nonconsecutive 24-h dietary recalls were collected.</p>	<p>Muscle Strength - Handgrip strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p> <p>Muscle Strength - Knee extensor</p> <p>Measure/Method of Assessment: Measured using isometric contraction of the knee extensors.</p> <p>Physical Performance - TUG</p> <p>Measure/Method of Assessment: Measures the time that takes to rise from a chair without using arms, walk 3 m at usual pace, turn, return to the chair, and sit down.</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	Mean physical activity level (SD): 94 (45) PASE score Health status/ Comorbidities: Chronic diseases 0: 3.5% 1–2: 26.1% ≥3: 70.4% Medication use: 0: 5.2% 1-4: 43.9% ≥5: 50.9% Supplement use: NR Pregnant or lactating: NR			
PMID: 18175749 Houston 2008 ⁷² Location/Country: USA HDI: Very high Setting: Community dwelling Urban/ Rural: Metropolitan Study design: Prospective cohort study Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 2066 Quintile 1: Protein intake cut-offs NR N: NR % Female: 53.3% Mean Age (SD): 74.4 (2.8) y Race/ Ethnicity: Black: 46.7% Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 27.2 (4.8) kg/m ² Income level: NR Education level: <High school: 25.9% Mean physical activity level (SD): Walking 115.8 (185.7) min/wk Health status/ Comorbidities: Diabetes: 15% Ischemic heart disease: 19.4% Congestive heart failure: 1.7% Cerebrovascular disease: 7% COPD: 10.9% Cancer: 16.2% Medication use: Oral steroids use: 2.7%	Quintile 1: Protein intake cut-offs NR Baseline Protein Amount Mean (SD): 56.9 (18.6) g/d; 0.8 (0.3) g/kg/d; 10.9% of energy Carbohydrate Mean (SD): 55.1% of energy Fat Mean (SD): 34.8% of energy Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Quintile 2: Protein intake cut-offs NR Baseline Protein Amount Mean (SD): 53.6 (19.8) g/d; 0.7 (0.3) g/kg/d; 12.7% of energy Carbohydrate Mean (SD): 55.1% of energy	Protein Assessment Method: Study participants completed a 108-item interviewer-administered FFQ. The FFQ was analyzed for micronutrient and macronutrient content by Block Dietary Data Systems	Muscle Mass - Total body lean mass Measure/Method of Assessment: DXA (Hologic 4500A, version 8.20a)

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 2: Protein intake cut-offs NR N: NR % Female: 53.3% Mean Age (SD): 74.7 (2.9) y Race/ Ethnicity: Black: 36.6% Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 27.1 (4.5) kg/m² Income level: NR Education level: <High school: 20.8% Mean physical activity level (SD): Walking 131.5 (281.0) min/wk Health status/ Comorbidities: Diabetes: 17% Ischemic heart disease: 20.8% Congestive heart failure: 1.7% Cerebrovascular disease: 9.2% COPD: 11.6% Cancer: 18.4% Medication use: Oral steroids use: 2.2% Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 3: Protein intake cut-offs NR N: NR % Female: 53.1% Mean Age (SD): 74.5 (2.9) y Race/ Ethnicity: Black: 32.4% Menopausal status: Postmenopausal Obesity status: NR</p>	<p>Fat Mean (SD): 33.2% of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 3: Protein intake cut-offs NR</p> <p>Baseline Protein Amount Mean (SD): 59.2 (18.1) g/d; 0.8 (0.3) g/kg/d; 14.2% of energy Carbohydrate Mean (SD): 53.5% of energy Fat Mean (SD): 33.6% of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 4: Protein intake cut-offs NR</p> <p>Baseline Protein Amount Mean (SD): 67.1 (19.2) g/d; 0.9 (0.3) g/kg/d; 15.9% of energy Carbohydrate Mean (SD): 52.7% of energy Fat Mean (SD): 32.5% of energy</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Mean BMI (SD): 27.0 (4.6) kg/m² Income level: NR Education level: <High school: 19.8% Mean physical activity level (SD): Walking 137.6 (231.5) min/wk Health status/ Comorbidities: Diabetes: 20.8% Ischemic heart disease: 17.6% Congestive heart failure: 2.4% Cerebrovascular disease: 6.3% COPD: 12.1% Cancer: 19.3% Medication use: Oral steroid use: 3.6% Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 4: Protein intake cut-offs NR N: NR % Female: 53.3% Mean Age (SD): 74.6 (2.9) y Race/ Ethnicity: Black: 29.8% Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 26.9 (4.3) kg/m² Income level: NR Education level: <High school: 20.6% Mean physical activity level (SD): Walking 147.5 (298.2) min/wk Health status/ Comorbidities: Diabetes: 20.8% Ischemic heart disease: 19.8% Congestive heart failure: 2.9%</p>	<p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quintile 5: Protein intake cut-offs NR</p> <p>Baseline Protein Amount Mean (SD): 91.0 (27.1) g/d; 1.2 (0.4) g/kg/d; 18.6% of energy Carbohydrate Mean (SD): 50.4% of energy Fat Mean (SD): 32.1% of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 3 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	<p>Cerebrovascular disease: 6.8% COPD: 9.9% Cancer: 18.6% Medication use: Oral steroid use: 2.9% Supplement use: NR Pregnant or lactating: NR</p> <p>Quintile 5: Protein intake cut-offs NR N: NR % Female: 53.3% Mean Age (SD): 74.5 (2.8) y Race/ Ethnicity: Black: 31.7% Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 28.0 (5.1) kg/m² Income level: NR Education level: <High school: 18.2% Mea physical activity level (SD): Walking 155.7 (265.4) min/wk Health status/ Comorbidities: Diabetes: 22.8% Ischemic heart disease: 21.6% Congestive heart failure: 2.9% Cerebrovascular disease: 7.5% COPD: 9.2% Cancer: 19.4% Medication use: Oral steroids use: 3.4% Supplement use: NR Pregnant or lactating: NR</p>			
PMID: 26857389 Isanejad 2016 ⁷³ Location/Country: Finland	Study of: Adults Total sample N: 552	Tertile 1: Protein intake ≤0.8 g of protein/kg/d Baseline Protein Amount	Protein Assessment Method: Baseline dietary intake was collected by using 3-d food record.	Muscle Mass - Lean mass Measure/Method of

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
<p>HDI: Very high Setting: Community dwelling Urban/ Rural: Urban Study design: Prospective cohort study Funding source: Nonprofit, academic Risk of bias score: Very high</p>	<p>Tertile 1: Protein intake ≤ 0.8 g of protein/kg/d N: 171 % Female: 100% Mean Age (SD): 68.0 (1.9) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 29.9 (4.4) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 100.2 (112.6) times/month x strenuousness Health status/ Comorbidities: NR Medication use: NR Supplement use: Ca and vitamin D Pregnant or lactating: NR</p> <p>Tertile 2: Protein intake 0.81–1.19 g of protein/kg/d N: 269 % Female: 100% Mean Age (SD): 67.8 (1.9) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 27.1 (3.9) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 106.4 (72.5) times/month x strenuousness Health status/ Comorbidities: NR Medication use: NR</p>	<p>Mean (SD): 51.4 (10.3) g/d; 16.4 (3.1) % of energy Carbohydrate Mean (SD): 165.7 (45.5) g/d Fat Mean (SD): 43.6 (14.5) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 2: Protein intake 0.81–1.19 g of protein/kg/d</p> <p>Baseline Protein Amount Mean (SD): 65.0 (10.2) g/d; 17.4 (2.5) % of energy Carbohydrate Mean (SD): 187.6 (37.0) g/d Fat Mean (SD): 53.9 (15.1) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3: Protein intake ≥ 1.2 g of protein/kg/d</p> <p>Baseline Protein Amount Mean (SD): 83.4 (14.1) g/d; 18.6 (3.1) % of energy Carbohydrate Mean (SD): 219.1 (46.3) g/d Fat Mean (SD): 63.1 (18.2) g/d</p>	<p>Subjects were instructed to write down everything they ate and drank and to evaluate the amount of food consumed using household measures. Nutritional intake from food was calculated using Nutrica program. Collected data provided.</p>	<p>Assessment: DXA (Lunar Prodigy)</p> <p>Muscle Strength - Handgrip strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p> <p>Muscle Strength - Knee extension</p> <p>Measure/ Method of Assessment: NR</p> <p>Muscle Strength - Chair rise test</p> <p>Measure/Method of Assessment: Number of chair rises in 30 seconds</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	<p>Supplement use: Ca and vitamin D Pregnant or lactating: NR</p> <p>Tertile 3: Protein intake ≥ 1.2 g of protein/kg/d N: 112 % Female: 100% Mean Age (SD): 67.7 (1.8) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 25.3 (3.4) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 111.4 (140.3) times/month x strenuousness Health status/ Comorbidities: NR Medication use: NR Supplement use: Ca and Vitamin D Pregnant or lactating: NR</p>	<p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 3 y</p>		
<p>PMID: 33740517 Kim 2021⁷⁴ Location/Country: Korea HDI: Very high Setting: NR Urban/ Rural: NR Study design: Prospective cohort study Funding source: NR Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 32,458</p> <p>Tertile 1 (Male): Protein intake <0.8 g/kg/d N: 5126 % Female: 0% Median Age (IQR): 57.0 (50.0-62.0) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Median BMI (IQR): 24.9 (23.3-26.7) kg/m² Income level: Low income: 11.4%</p>	<p>Tertile 1 (Male): Protein intake <0.8 g/kg/d</p> <p>Baseline Protein Amount Median (IQR): 45.3 (38.9-51.7) g/d; 12.5 (11.3-14.0) % of energy Carbohydrate Median (IQR): 73.0 (68.3-76.7) % of energy Fat Median (IQR): 13.1 (10.0-16.8) % of energy</p> <p>Protein Amount at the end of the study Median (IQR): NR</p>	<p>Protein Assessment Method: Subjects' dietary protein intake was assessed using the 103-item semi-quantitative FFQ at baseline and the follow-up surveys. The FFQ is used to estimate nutrient intake from portion size and the frequency of food consumption. Protein was estimated from the sum of the intake of each food item, based on the food composition tables.</p>	<p>Muscle Strength - Handgrip strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Education level: ≤Elementary school: 1.3% Middle or high school: 23.3% ≥College: 75.4% Physical activity level: NR Health status/ Comorbidities: Diabetes: 11.6% Hypertension: 28.9% Dyslipidemia: 12.9% Stroke: 2.1% Coronary artery disease: 5.4% Cancer: 3.1% Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Tertile 2 (Male): Protein intake 0.8-1.2 g/kg/d N: 4449 % Female: 0% Median Age (IQR): 56.0 (49.0-62.0) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Median BMI (IQR): 24.1 (22.5-25.8) kg/m² Income level: Low income: 8.0% Education level: ≤Elementary school: 0.9% Middle or high school: 17.6% ≥College: 81.5% Physical activity level: NR Health status/ Comorbidities: Diabetes: 10.1% Hypertension: 23.7% Dyslipidemia: 12.2% Stroke: 1.8% Coronary artery disease: 4.3% Cancer: 2.8% Medication use: NR</p>	<p>Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Tertile 2 (Male): Protein intake 0.8-1.2 g/kg/d</p> <p>Baseline Protein Amount Median (IQR): 65.6 (58.8-73.4) g/d; 13.1 (11.8-14.7) % of energy Carbohydrate Median (IQR): 70.9 (66.1-74.9) % of energy Fat Median (IQR): 14.9 (11.6-18.5) % of energy</p> <p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Tertile 3 (Male): Protein intake >1.2 g/kg/d</p> <p>Baseline Protein Amount Median (IQR): 94.8 (83.9-109.7) g/d; 13.7 (12.3-15.6) % of energy Carbohydrate Median (IQR): 69.2 (63.7-73.3) % of energy Fat Median (IQR): 16.2 (12.8-20.4) % of energy</p> <p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Supplement use: NR Pregnant or lactating: NA</p> <p>Tertile 3 (Male): Protein intake >1.2 g/kg/d N: 1783 % Female: 0 Median Age (IQR): 55.0 (48.0-62.0) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Median BMI (IQR): 23.6 (21.8-25.3) kg/m² Income level: Low income: 8.3% Education level: ≤Elementary school: 1.1%, Middle or high school: 16.8%, ≥College: 82.1% Physical activity level: NR Health status/ Comorbidities: Diabetes: 7.2% Hypertension: 20.5% Dyslipidemia: 9.0% Stroke: 1.1% Coronary artery disease: 2.7% Cancer: 3.5% Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Tertile 1 (Female): Protein intake <0.8 g/kg/d N: 7545 % Female: 23.2% Median Age (IQR): 54.0 (49.-60.0) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR</p>	<p>Tertile 1 (Female): Protein intake <0.8 g/kg/d</p> <p>Baseline Protein Amount Median (IQR): 38.5 (32.8-43.6) g/d; 12.6 (11.2-14.3) % of energy Carbohydrate Median (IQR): 73.5 (68.5-77.7) % of energy Fat Median (IQR): 12.8 (9.4-16.9) % of energy</p> <p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Tertile 2 (Female): Protein intake 0.8-1.2 g/kg/d</p> <p>Baseline Protein Amount Median (IQR): 55.4 (49.9-61.7) g/d; 13.2 (11.8-14.9) % of energy Carbohydrate Median (IQR): 71.6 (66.7-75.7) % of energy Fat Median (IQR): 14.4 (11.0-18.3) % of energy</p> <p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Tertile 3 (Female): Protein intake >1.2 g/kg/d</p> <p>Baseline Protein Amount</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Median BMI (IQR): 24.2 (22.4-26.3) kg/m² Income level: Low income: 15.3% Education level: ≤Elementary school: 3.4% Middle or high school: 40.6% ≥College: 56.0% Physical activity level: NR Health status/ Comorbidities: Diabetes: 6.9% Hypertension: 22.7% Dyslipidemia: 13.4% Stroke: 0.9% Coronary artery disease: 2.5% Cancer: 4.8% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 2 (Female): Protein intake 0.8-1.2 g/kg/d N: 8644 % Female: 26.6% Median Age (IQR): 52.0 (47.0-58.0) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Median BMI (IQR): 23.1 (21.5-25.0) kg/m² Income level: Low income: 9.1% Education level: ≤Elementary school: 1.8% Middle or high school: 29.9% ≥College: 68.3% Physical activity level: NR Health status/ Comorbidities: Diabetes: 4.5% Hypertension: 16.7% Dyslipidemia: 10.7%</p>	<p>Median (IQR): 80.4 (71.1-3.7) g/d; 14.0 (12.5-15.7) % of energy Carbohydrate Median (IQR): 69.1 (64.0-73.8) % of energy Fat Median (IQR): 16.4 (12.6-20.3) % of energy</p> <p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 4 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	<p>Stroke: 0.6% Coronary artery disease: 1.9% Cancer: 4.5% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 3 (Female): Protein intake >1.2 g/kg/d N: 4911 % Female: 15.1% Median Age (IQR): 51.0 (46.0-57.0) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Median BMI (IQR): 22.3 (20.7-24.1) kg/m² Income level: Low income: 6.9% Education level: ≤Elementary school: 1.1% Middle or high school: 21.1%, ≥College: 77.8% Physical activity level: NR Health status/ Comorbidities: Diabetes: 3.3% Hypertension: 12.4% Dyslipidemia: 9.5% Stroke: 0.6% Coronary artery disease: 1.2% Cancer: 4.6% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>			
<p>PMID: 28179224 Mangano 2017^{*22} Location/Country: USA HDI: Very high Setting: NR Urban/ Rural: NR</p>	<p>Study of: Adults Total sample N: 2,986</p> <p>Arm 1: Protein food cluster (Fast food, full-fat dairy) N: 458 % Female: 44%</p>	<p>Arm 1: Protein food cluster (Fast food, full-fat dairy)</p> <p>Baseline Protein Amount Mean (SD): 88 (31) g/d Carbohydrate Mean (SD): NR</p>	<p>Protein Assessment Method: Typical dietary intakes of foods and nutrients were assessed with the use of the Harvard 126-item semiquantitative and</p>	<p>Muscle Mass - Lean mass</p> <p>Measure/Method of Assessment: DXA Fan beam densitometer (GE Lunar Prodigy)</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
<p>Study design: Prospective cohort study Funding source: Government Risk of bias score: High</p>	<p>Mean Age (SD): 39.3 (8.5) y Race/ Ethnicity: NR Menopausal status: 6% nonestrogenic Obesity status: NR Mean BMI (SD): 26.5 (5.0) kg/m² Income level: NR Education level: NR Mean physical activity level: 37.2 (7.4) PAI Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 19%, Vitamin D supplements: 40% Pregnant or lactating: NR</p> <p>Arm 2: Protein food cluster 2 (Fish) N: 605 % Female: 58% Mean Age (SD): 42.2 (9.0) y Race/ Ethnicity: NR Menopausal status: 14% nonestrogenic Obesity status: NR Mean BMI (SD): 26.8 (5.3) kg/m² Income level: NR Education level: NR Mean physical activity level: 37.4 (7.6) PAI Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 43%, Vitamin D supplements: 53% Pregnant or lactating: NR</p>	<p>Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 2: Protein food cluster 2 (Fish)</p> <p>Baseline Protein Amount Mean (SD): 90 (31) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 3: Protein food cluster 3 (Red meat)</p> <p>Baseline Protein Amount Mean (SD): 97 (29) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p>	<p>validated general population 88 FFQ. Protein intake was assessed during the years 2002-2005.</p>	<p>Muscle Mass - Appendicular lean mass/ skeletal muscle mass</p> <p>Measure/Method of Assessment: DXA Fan beam densitometer (GE Lunar Prodigy)</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Arm 3: Protein food cluster 3 (Red meat) N: 640 % Female: 48% Mean Age (SD): 41.5 (8.3) y Race/ Ethnicity: NR Menopausal status: 13% nonestrogenic Obesity status: NR Mean BMI (SD): 27.4 (5.6) kg/m² Income level: NR Education level: NR Mean physical activity level: 37.5 (8.3) PAI Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 30% Vitamin D supplements: 39% Pregnant or lactating: NR</p> <p>Arm 4: Protein food cluster 4 (Chicken) N: 735 % Female: 58% Mean Age (SD): 39.3 (8.3) y Race/ Ethnicity: NR Menopausal status: 7% nonestrogenic Obesity status: NR Mean BMI (SD): 26.7 (5.3) kg/m² Income level: NR Education level: NR Mean physical activity level: 37.0 (7.2) PAI Health status/ Comorbidities: NR Medication use: NR Supplement use:</p>	<p>Arm 4: Protein food cluster 4 (Chicken) Baseline Protein Amount Mean (SD): 95 (35) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 5: Protein food cluster 5 (Low-fat milk) Baseline Protein Amount Mean (SD): 98 (31) g/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 6: Protein food cluster 6 (Legumes) Baseline Protein Amount Mean (SD): 83 (34) g/d Carbohydrate: NR Fat: NR</p> <p>Protein Amount at the end of the study</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Calcium supplements: 36%, Vitamin D supplements: 46% Pregnant or lactating: NR</p> <p>Arm 5: Protein food cluster 5 (Low-fat milk) N: 434 % Female: 58% Mean Age (SD): 40.9 (8.6) y Race/ Ethnicity: NR Menopausal status: 11% nonestrogenic Obesity status: NR Mean BMI (SD): 26.8 (5.0) kg/m² Income level: NR Education level: NR Mean physical activity level: 37.8 (7.3) PAI Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 40%, Vitamin D supplements: 50% Pregnant or lactating: NR</p> <p>Arm 6: Protein food cluster 6 (Legumes) N: 114 % Female: 79% Mean Age (SD): 38.6 (9.4) y Race/ Ethnicity: NR Menopausal status: 7% nonestrogenic Obesity status: NR Mean BMI (SD): 23.9 (4.6) kg/m² Income level: NR Education level: NR Mean physical activity level: 36.1 (5.8) PAI</p>	<p>Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 9 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	Health status/ Comorbidities: NR Medication use: NR Supplement use: Calcium supplements: 47%, Vitamin D supplements: 56% Pregnant or lactating: NR			
PMID: 33829238 Mendonca 2021⁷⁵ Location/Country: USA, Canada, Netherlands and UK HDI: Very high Setting: Mixed Urban/ Rural: Mixed Study Design: Pooled analysis of longitudinal observational study Funding source: NR Risk of bias: Very high	Study of: Adults Total sample N: 5725 Quartile 1: Protein intake <0.8 g/kg aBW/d N:1579 % Female: 53.8% Median Age (IQR): 75.0 (72.0–79.0) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: Low: 31.1% Medium: 36.8% High: 32.1% Physical activity level: Low: 36.7% Medium: 34.1% High: 29.1% Health status/ Comorbidities: Multimorbidity: 49.6% Medication use: NR Supplement use: NR Pregnant or lactating: NR Quartile 2: Protein intake 0.8–0.99 g/kg aBW/d N:1335 % Female: 57.7% Median Age (IQR): 75.0 (72.0–79.2) y	Pooled analysis Quartile 1: Protein intake <0.8 g/kg aBW/d Baseline Protein Amount Mean (SD): <0.8 g/kg aBW/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Quartile 2: Protein intake 0.8–0.99 g/kg aBW/d Baseline Protein Amount Mean (SD): 0.8–0.99 g/kg aBW/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR	Protein Assessment Method: Dietary intake was assessed by an FFQ and multiple 24-h recalls. Protein intake was expressed as a categorical variable using cut points of (<0.8,0.8–0.99, 1.0–1.19, ≥1.2) based on expert recommendations for optimal protein intake on currently used RDAs for protein.	Physical Performance - Walking speed Measure/Method of Assessment: Measured as the time taken to walk a distance that varied between cohorts. One cohort did not measure walking speed so the formula [6/TUG (s)]×1.62 was used to yield walking speed.

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: Low: 33.2% Medium: 36.4% High: 30.4% Physical activity level: Low: 30.0% Medium: 35.5% High: 34.5% Health status/ Comorbidities: Multimorbidity: 52.6% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 3: Protein intake 1.0–1.19 g/kg aBW/d N: 1218 % Female: 53.5% Median Age (IQR): 75.0 (71.0–79.0) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: Low: 30.1% Medium: 37.8% High: 32.1% Physical activity level: Low: 32.6% Medium: 34.7% High: 32.7% Health status/ Comorbidities: Multimorbidity: 53.0%</p>	<p>Quartile 3: Protein intake 1.0–1.19 g/kg aBW/d</p> <p>Baseline Protein Amount Mean (SD): 1.0–1.19 g/kg aBW/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 4: Protein intake \geq1.2 g/kg aBW/d</p> <p>Baseline Protein Amount Mean (SD): \geq1.2 g/kg aBW/d Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 8.5y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 4: Protein intake ≥ 1.2 g/kg aBW/d N:1593 % Female: 51.3% Median Age (IQR): 75.0 (71.0–79.0) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: Low: 32.8% Medium: 39.5% High: 27.6% Physical activity level: Low: 29.6% Medium: 31.5% High: 38.9% Health status/ Comorbidities: Multimorbidity: 49.6% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>			
<p>PMID: 35791789 Mendonca 2023⁷⁶ Location/Country: USA, Canada, Netherlands, UK HDI: Very high Setting: Mixed Urban/Rural: Mixed Study design: Pooled analysis of longitudinal observational study Funding source: Nonprofit</p>	<p>Study of: Adults Total sample N: 5584</p> <p>Quartile 1: Protein intake < 0.8 g of protein/kg aBW/d N: 1530 % Female: 53.5% Median Age (IQR): 75.0 (72.0–79.0) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR</p>	<p>Quartile 1: Protein intake < 0.8 g of protein/kg aBW/d</p> <p>Baseline Protein Amount Mean (SD): 44.1 (10.9) g/d; 0.6 (0.1) g/kg aBW/d; 13.6 (2.8) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study</p>	<p>Protein Assessment Method: Dietary intake was assessed by an FFQ and multiple 24-h recalls. Protein intake was expressed as a categorical variable using cut points of ($< 0.8, 0.8–0.99, 1.0–1.19, \geq 1.2$) based on expert recommendations for optimal protein intake on</p>	<p>Muscle Strength - Grip strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
<p>Risk of bias score: Very high</p>	<p>Mean BMI (SD): 27.7 (4.5) kg/m² Income level: NR Education level: Lower: 31.8% Medium: 37.0% Higher: 32.0% Physical activity level: Lower: 36.5% Medium: 34.2% Higher: 29.3% Health status/ Comorbidities: Multimorbidity: 49.4% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 2: Protein intake 0.8– <1.0g/kg aBW/d N: 1304 % Female: 53.2% Median Age (IQR): 75.0 (72.0–79.5) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 27.1 (4.7) kg/m² Income level: NR Education level: Lower: 33.4% Medium: 36.3% Higher: 30.3% Physical activity level: Lower: 30.2% Medium: 35.2% Higher: 34.6% Health status/ Comorbidities: Multimorbidity: 52.2% Medication use: NR Supplement use: NR</p>	<p>Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 2: Protein intake 0.8– <1.0g/kg aBW/d</p> <p>Baseline Protein Amount Mean (SD): 62.3 (9.1) g/d; 0.9 (0.1) g/kg aBW/d; 14.8 (3.0) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Quartile 3: Protein intake 1.0–<1.2 g/kg aBW/d</p> <p>Baseline Protein Amount Mean (SD): 75.2(10.7) g/d; 1.1 (0.1) g/kg aBW/d; 15.8 (2.9) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p>	<p>currently used RDAs for protein.</p>	

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Pregnant or lactating: NR</p> <p>Quartile 3: Protein intake 1.0–<1.2 g/kg aBW/d N: 1195 % Female: 53.3% Median Age (IQR): 75.0 (71.0–79.0) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 26.9 (4.7) kg/m² Income level: NR Education level: Lower: 29.9% Medium: 38.1% Higher: 32.0% Physical activity level: Lower: 32.6% Medium: 34.4% Higher: 33.0% Health status/ Comorbidities: Multimorbidity: 52.9% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Quartile 4: Protein intake ≥1.2 g/kg aBW/d N: 1555 % Female: 50.7% Median Age (IQR): 74.0 (70.8–79.0) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 26.3 (5.0) kg/m² Income level: NR</p>	<p>Quartile 4: Protein intake ≥1.2 g/kg aBW/d</p> <p>Baseline Protein Amount Mean (SD): 97.9 (20.4) g/d; 1.5 (0.3) g/kg aBW/d; 17.1 (3.2) % of energy Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 8.5 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	Education level: Lower: 32.8% Medium: 39.5% Higher: 27.7% Physical activity level: Lower: 29.4% Medium: 31.5% Higher: 39.1% Health status/ Comorbidities: Multimorbidity: 49.4% Medication use: NR Supplement use: NR Pregnant or lactating: NR			
PMID: 19419320 Meng 2009 ^{*23} Location/Country: Australia HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: Prospective cohort study Funding source: Nonprofit, government Risk of bias score: High	Study of: Adults Total sample N: 862 Tertile 1: Protein intake <66 g of protein/ d N: 287 % Female: 100% Mean Age (SD): 74.9 (2.5) y Race/ Ethnicity: 100% white origin Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 26.4 (4.2) kg/m ² Income level: NR Education level: NR Physical activity level: 466 (median kilojoules expended per day) Health status/ Comorbidities: Participants were excluded if they had a medical condition likely to influence 5-year survival. Medication use: Participants were excluded if they were taking bone active medications including calcium	Tertile 1: Protein intake <66 g of protein g/d Baseline Protein Amount Mean (SD): 54.4 (9.1) g/d Carbohydrate Mean (SD): 146.8 (30.9) g/d Fat Mean (SD): 46.4 (13.3) g/d Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Tertile 2: Protein intake 66-87 g of protein/ d Baseline Protein Amount Mean (SD): 76.6 (6.2) g/d Carbohydrate Mean (SD): 186.4 (34.1) g/d Fat Mean (SD): 63.0 (13.3) g/d Protein Amount at the end of the study	Protein Assessment Method: Participants completed a self-administered, quantitative FFQ. This FFQ has been designed to measure eating habits over the past 12-mo period and calibrated and validated according to the foods and on intake for a 12-mo period. The daily dietary intakes were derived from the questionnaire. Protein intake was assessed at baseline.	Muscle Mass - Lean mass Measure/Method of Assessment: DXA (Hologic 4500A machine, Hologic, Boston, MA, USA) Muscle Mass - Appendicular lean mass/ skeletal muscle mass Measure/Method of Assessment: DXA (Hologic 4500A machine, Hologic, Boston, MA, USA)

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>supplements, estrogen, bisphosphonates, and vitamin D. Supplement use: Participants were excluded if they were taking bone active medications including calcium supplements, estrogen, bisphosphonates, and vitamin D. Pregnant or lactating: NR</p> <p>Tertile 2: Protein intake 66-87 g of protein/ d N: 287 % Female: 100% Mean Age (SD): 75.0 (2.6) y Race/ Ethnicity: 100% white origin Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 26.7 (4.7) kg/m² Income level: NR Education level: NR Physical activity level: 530 (median kilojoules expended per day) Health status/ Comorbidities: Participants were excluded if they had a medical condition likely to influence 5-year survival. Medication use: Participants were excluded if they were taking bone active medications including calcium supplements, estrogen, bisphosphonates, and vitamin D.</p>	<p>Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3: Protein intake >87 g of protein/d</p> <p>Baseline Protein Amount Mean (SD): 110.9 (23.4) g/d Carbohydrate Mean (SD): 249.5 (61.9) g/d Fat Mean (SD): 85.1 (25.7) g/d</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 5 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Supplement use: Participants were excluded if they were taking bone active medications including calcium supplements, estrogen, bisphosphonates, and vitamin D. Pregnant or lactating: NR</p> <p>Tertile 3: Protein intake >87 g of protein/ d N: 288 % Female: 100% Mean Age (SD): 74.7 (2.7) y Race/ Ethnicity: 100% white origin Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 27.3 (4.3) kg/m² Income level: NR Education level: NR Physical activity level: 614 (median kilojoules expended per day) Health status/ Comorbidities: Participants were excluded if they had a medical condition likely to influence 5-year survival. Medication use: Participants were excluded if they were taking bone active medications including calcium supplements, estrogen, bisphosphonates, and vitamin D. Supplement use: Participants were excluded if they were taking bone active medications including calcium</p>			

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	supplements, estrogen, bisphosphonates, and vitamin D. Pregnant or lactating: NR			
PMID: 22923606 Mulla 2013 ⁷⁷ Location/Country: UK HDI: Very high Setting: NR Urban/ Rural: NR Study design: Prospective cohort design Funding source: Nonprofit Risk of bias score: High	Study of: Adults Total sample N: 1771 Arm 1: Men N: 867 % Female: 0% Age: 36 Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NA Arm 2: Women N: 904 % Female: 100% Age: 36 Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): NR Income level: NR Education level: NR Physical activity level: NR Health status/ Comorbidities: NR Medication use: NR Supplement use: NR Pregnant or lactating: NR	Arm 1: Men Baseline Protein Amount Mean (SD): 84 (19) g/d; 14.4 (2.4) % of energy Carbohydrate Mean (SD): 263 (75) g/d Fat Mean (SD): 103 (30) g/d Protein Amount at the end of the study Mean (SD): 88 (21) g/d; 14.6 (2.3) % of energy Carbohydrate Mean (SD): 267 (73) g/d Fat Mean (SD): 108 (32) g/d Arm 2: Women Baseline Protein Amount Mean (SD): 64 (15) g/d; 15.7 (3.6) % of energy Carbohydrate Mean (SD): 191 (64) g/d Fat intake Mean (SD): 77 (25) g/d Protein Amount at the end of the study Mean (SD): 70 (16) g/d; 15.5 (3.0) % of energy Carbohydrate Mean (SD): 208 (60) g/d Fat Mean (SD): 82 (26) g/d Protein type/source: Mixed	Protein Assessment Method: Food record (5-day estimated diaries) nutrient intakes for both time points were calculated based on McCance and Widdowson's.	Muscle Strength - Grip strength Measure/Method of Assessment: Measured using handgrip dynamometer Muscle Strength - Chair rise test Measure/Method of Assessment: Measured as the time taken to rise from a sitting to standing position with a straight back and legs and then sit down again.

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
		Energy balance status: Eucaloric Study duration: 16 y		
PMID: 31608843 Otsuka 2020 ⁷⁸ Location/Country: Japan HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: Prospective cohort study Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 655 Arm 1: Men N: 292 % Female: 0% Mean Age (SD): 68.8 (6) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 24.3 (2.2) kg/m ² Income level: Annual family income <3,500,000 Yen: 27.4% Education level: ≤ 9 years: 27.4% Mean physical activity level (SD): 34.1 (3.80) MET x h/d Health status/ Comorbidities: Heart disease: 7.9% Hypertension: 46.9% Dyslipidemia: 23% Diabetes: 12% Medication use: NR Supplement use: NR Pregnant or lactating: NA Arm 2: Women N: 363 % Female: 100% Mean Age (SD): 69.8 (6.5) y Race/ Ethnicity: NR Menopausal status: Postmenopausal Obesity status: NR Mean BMI (SD): 23.5 (2.8) kg/m ²	Arm 1: Men Baseline Protein Amount Mean (SD): 86.7 (17.4) g/d Carbohydrate Mean (SD): 317.7 (60.5) g/d Fat Mean (SD): 56.6 (15.6) g/d Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Arm 2: Women Baseline Protein Amount Mean (SD): 71.0 (13.4) g/d Carbohydrate Mean (SD): 266.3 (49.8) g/d Fat Mean (SD): 48.8 (12.4) g/d Protein Amount at the end of the study: NR Carbohydrate intake: NR Fat intake: NR Protein type/ source: mixed type. Energy balance status: Eucaloric Study duration: 2 y	Protein Assessment Method: Three-day dietary record nutrient intakes were calculated according to the Standard Tables of Food Composition in Japan 2010. Within each meal sheet, i.e., the breakfast, lunch and dinner sheet, most participants recorded the time and all foods containing seasonings that they consumed.	Muscle Mass – Appendicular lean mass/ skeletal muscle mass Measure/Method of Assessment: DXA (QDR-4500; Hologic, Bedford, MA, USA)

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	Income level: Annual family income <3,500,000 Yen: 41.3% Education level: ≤ 9 years: 32.5% Mean physical activity level (SD): 35.1 (2.6) MET x h/d Health status/ Comorbidities: Heart disease: 4.7% Hypertension: 41.3% Dyslipidemia: 30.0% Diabetes: 11.6% Medication use: NR Supplement use: NR Pregnant or lactating: NR			
PMID: 26179475 Rahi 2016 ⁷⁹ Location/Country: Canada HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: Prospective cohort study Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 172 Arm 1 (Men): Protein intake ≥1 g/kg/d N: 43 % Female: 0% Mean Age (SD): 74.9 (4.4) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 28.4 (3.6) kg/m ² Income level: NR Mean education level (SD): 12.5 (5.5) y Physical activity level: NR Health status/ Comorbidities: Participants free from heart failure greater than class II, chronic obstructive pulmonary disease requiring oxygen therapy or oral steroids, inflammatory digestive diseases, or cancer treated by radiation therapy, chemotherapy, or surgery	Arm 1 (Men): Protein intake ≥1 g/kg/d Baseline Protein Amount Mean (SD): 97.6 (18.0) g/d; 1.24 (0.22) g/kg/d; 18.7 (3.3) % of energy Carbohydrate Mean (SD): 45.9 (7.4) % of energy Fat Mean (SD): 35.3 (6.0) % of energy Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR Arm 2 (Men): Protein intake <1g/kg/d Baseline Protein Intake Mean (SD): 70.0 (16.0) g/d; 0.78 (0.15) g/kg/d; 16.1 (3.3) % of energy Carbohydrate Mean (SD):	Protein Assessment Method: Dietary assessments were conducted by three non-consecutive 24-h dietary recalls (24-HR) on two randomly chosen weekdays and 1 weekend day. Recalls were processed using the CANDAT nutrient analysis program based on the then-current Canadian Nutrient File (CNF) database version 2001b. NR	Muscle Strength - Knee extensors Measure/Method of Assessment: Measured using isometric contraction of the knee extensors.

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Arm 2 (Men): Protein intake <1 g/kg/d N: 63 % Female: 0% Mean Age (SD): 74.9 (4.4) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 31.4 (4.4) kg/m² Income level: NR Mean education level (SD): 11.5 (5.2) y Physical activity level: NR Health status/ Comorbidities: Participants free from heart failure greater than class II, chronic obstructive pulmonary disease requiring oxygen therapy or oral steroids, inflammatory digestive diseases, or cancer treated by radiation therapy, chemotherapy, or surgery. Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Arm 3 (Women): Protein intake ≥1 g/kg/d N: 30 % Female: 100% Mean Age (SD): 74.2 (4.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.1 (3.2) kg/m²</p>	<p>48.1 (7.6) % of energy Fat Mean (SD): 35.2 (6.4) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 3 (Women): Protein intake ≥1 g/kg/d</p> <p>Baseline Protein Amount Mean (SD): 84.4 (20.6) g/d; 1.32 (0.31) g/kg/d; 19.2 (3.4) % of energy Carbohydrate Mean (SD): 45.8 (5.4) % of energy Fat Mean (SD): 35.3 (4.9) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Arm 4 (Women): Protein intake <1 g/kg/d</p> <p>Baseline Protein Amount Mean (SD): 58.6 (12.5) g/d; 0.78 (0.14) g/kg/d; 16.4 (3.6) % of energy Carbohydrate Mean (SD): 51.0 (6.9) % of energy Fat Mean (SD): 33.1 (6.1) % of energy</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Income level: NR Mean education level (SD): 10.2 (3.1) y Physical activity level: NR Health status/ Comorbidities: Participants free from heart failure greater than class II, chronic obstructive pulmonary disease requiring oxygen therapy or oral steroids, inflammatory digestive diseases, or cancer treated by radiation therapy, chemotherapy, or surgery. Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Arm 4 (Women): Protein intake <1 g/kg/d N: 30 % Female: 100% Mean Age (SD): 75.8 (4.3) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NA Mean BMI (SD): 31.4 (4.6) kg/m² Income level: NR Mean education level (SD): 10.2 (3.0) y Physical activity level: NR Health status/ Comorbidities: Participants free from heart failure greater than class II, chronic obstructive pulmonary disease requiring oxygen therapy or oral steroids, inflammatory digestive diseases, or cancer treated by radiation therapy, chemotherapy, or surgery.</p>	<p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 3 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
	Medication use: NR Supplement use: NR Pregnant or lactating: NR			
PMID: 21054294 Scott 2010 ⁸⁰ Location/Country: Australia HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: Prospective cohort study Funding source: Nonprofit, government, academic Risk of bias score: High	Study of: Adults Total sample N: 1,099 Whole Cohort N: 1099 % Female: 50.1% Mean Age (SD): 61.9 (7.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 27.5 (4.5) kg/m ² Income level: NR Education level: NR Mean physical activity level (SD): 8,877.0 (3,546) steps/d Health status/ Comorbidities: Excluded those with contraindication for MRI or who were institutionalized Medication use: NR Supplement use: NR Pregnant or lactating: NR	Whole Cohort Baseline Protein Amount Mean (SD): 87.6 (33.7) g/d Carbohydrate Mean (SD): 213.7 (73.9) g/d Fat Mean (SD): 73.0 (29.6) g/d Protein Amount at the end of the study Mean (SD): 88.0 (33.7) g/d Carbohydrate Mean (SD): 205.3 (76.7) g/d Fat Mean (SD): 72.2 (30.9) g/d Protein type/ source: Mixed Energy balance status: Eucaloric Study duration: 3 y	Protein Assessment Method: Dietary nutrient intake was assessed using The Cancer Council Victoria's self-administered Food Frequency Ques (FFQ). The output included average daily estimates for total energy intake and for 28 dietary nutrients. Macronutrient intakes for baseline and follow-up reported.	Muscle Mass - Appendicular lean mass/ skeletal muscle mass Measure/Method of Assessment: DXA (Hologic Delphi densitometer, Hologic, Waltham, MA) Muscle Strength - Knee extension Measure/Method of Assessment: Measured using isometric contraction of the knee extensors.
PMID: 32825743 So 2020 ⁸¹ Location/Country: Korea HDI: Very high Setting: Community dwelling, Urban/ Rural: Urban and rural Study design: Prospective cohort study Funding source: Government Risk of bias score: High	Study of: Adults Total sample N: 4412 Tertile 1 (Men): Protein intake cut-offs NR N: NR % Female: 0% Mean Age (SD): 50.9 (8.2) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 24.4 (2.8) kg/m ² Income level: ≥ 3,000,000 KRW: 22.0%	Tertile 1 (Men): Protein intake cut-offs NR Baseline Protein Amount Mean (SD): 61.1 (0.9) g/d; 13.1 (0.1) % of energy Carbohydrate Mean (SD): 71.6 (0.2) % of energy Fat Mean (SD): 13.9 (0.2) % of energy Protein Amount at the end of the study Mean (SD): NR	Protein Assessment Method: Dietary intake was assessed using a 103-item, semi-quantitative FFQ. Daily nutrient intake was calculated based on the seventh edition of the Food Composition Table in Korea.	Muscle Mass - Lean mass Measure/Method of Assessment: BIA (MF-BIA, Inbody 3.0, Biospace) Muscle Mass - SMI Measure/Method of Assessment: Skeletal muscle mass estimated by dividing total lean mass by 0.52. SMI calculated as total skeletal muscle mass/weight x100.

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Education level: ≥ College: 18.8% Mean physical activity level (SD): 23.9 (15.5) METs h/d Health status/ Comorbidities: Poor dental health: 39.9% Chronic disease: 1.8% Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Tertile 2 (Men): Protein intake cut-offs NR N: NR % Female: 0% Mean Age (SD): 49.1 (7.5) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 24.5 (2.8) kg/m² Income level: ≥ 3,000,000 KRW: 29.9% Education level: ≥ College: 27.8% Mean physical activity level (SD): 21.8 (13.4) METs h/d Health status/ Comorbidities: Poor dental health: 37.2% Chronic disease: 1.0% Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Tertile 3 (Men): Protein intake cut-offs NR N: NR % Female: 0% Mean Age (SD): 50.4 (7.9) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR</p>	<p>Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 2 (Men): Protein intake cut-offs NR</p> <p>Baseline Protein Amount Mean (SD): 70.0 (0.9) g/d; 13.9 (0.1) % of energy Carbohydrate Mean (SD): 68.9(0.2) % of energy Fat Mean (SD): 16.1 (0.2) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3 (Men): Protein intake cut-offs NR</p> <p>Baseline Protein Amount Mean (SD): 77.9 (0.9) g/d; 17.3 (0.2) % of energy Carbohydrate Mean (SD): 67.5 (0.2) % of energy Fat Mean (SD): 17.3 (0.2) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 1 (Women): Protein intake cut-offs NR</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Mean BMI (SD): 24.3 (2.6) kg/m² Income level: ≥ 3,000,000 KRW: 30.6% Education level: ≥College: 29.8% Mean physical activity level (SD): 21.8 (13.4) METs h/d Health status/ Comorbidities: Poor dental health: 38.8% Chronic disease: 1.4% Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Tertile 1 (Women): Protein intake cut-offs NR N: NR % Female: 100% Mean Age (SD): 52.8 (9.0) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.8 (3.0) kg/m² Income level: ≥3,000,000 KRW: 10.7% Education level: ≥College: 3.7% Mean physical activity level (SD): 24.4 (15.1) METs h/d Health status/ Comorbidities: Poor dental health: 45.8% Chronic disease: 6.8% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 2 (Women): Protein intake cut-offs NR N: NR % Female: 100%</p>	<p>Baseline Protein Amount (Mean SD): 53.7 (0.8) g/d; 12.5 (0.1) % of energy Carbohydrate Mean (SD): 75.1 (0.2) % of energy Fat Mean (SD): 11.1 (0.2) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 2 (Women): Protein intake cut-offs NR</p> <p>Baseline Protein Amount Mean (SD): 63.3 (0.8) g/d; 13.6 (0.1) % of energy Carbohydrate Mean (SD): 71.4 (0.2) % of energy Fat Mean (SD): 14.1 (0.2) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Tertile 3 (Women): Protein intake cut-offs NR</p> <p>Baseline Protein Amount Mean (SD): 72.6 (0.8) g/d; 14.1 (0.1) % of energy Carbohydrate Mean (SD): 69.0 (0.2) % of energy</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Mean Age (SD): 49.4 (7.9) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.7 (2.9) kg/m² Income level: ≥3,000,000 KRW:20.6% Education level: ≥College: 10.0% Mean physical activity level (SD): 20.9 (12.9) METs h/d Health status/ Comorbidities: Poor dental health: 39.0% Chronic disease: 4.0% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Tertile 3 (Women): Protein intake cut-offs NR N: NR % Female: 100% Mean Age (SD): 50.6 (8.1) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 24.4 (2.9) kg/m² Income level: ≥3,000,000 KRW: 19.5% Education level: ≥College: 10.1% Mean physical activity level (SD): 21.7 (13.1) METs- h/d Health status/ Comorbidities: Poor dental health: 40.9% Chronic disease: 3.0% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p>	<p>Fat Mean (SD): 16.1 (0.2) % of energy</p> <p>Protein Amount at the end of the study Mean (SD): NR Carbohydrate Mean (SD): NR Fat Mean (SD): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 12 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods (of assessment))	Outcome (Measures and methods of assessment)
<p>PMID: 34124824 Wham 2021⁸² Location/Country: New Zealand HDI: Very high Setting: Community dwelling Urban/ Rural: NR Study design: Prospective cohort study Funding source: Government Risk of bias score: High</p>	<p>Study of: Adults Total sample N: 554</p> <p>Arm 1: Māori women N: 116 % Female: 57% Mean Age (SD): 83.56 (2.62) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 28.86 (6.41) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 96.77 (87.23) PASE Health status/ Comorbidities: Rheumatoid arthritis: 28.6% Osteoarthritis: 35.7% Asthma or chronic lung disease: 34.8% Congestive heart failure: 29.0% Diabetes: 29.8% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Arm 2: Māori men N: 86 % Female: 0% Mean Age (SD): 82.94 (2.65) y Race/ Ethnicity: NR Menopausal status: NA Obesity status: NR Mean BMI (SD): 28.68 (5.29) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 111.65 (79.38) PASE Health status/ Comorbidities:</p>	<p>Arm 1: Māori women</p> <p>Baseline Protein Amount Median (IQR): 0.86 (0.64-1.11) g/kg/d Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Arm 2: Māori men</p> <p>Baseline Protein Amount Median (IQR): 0.97 (0.73-1.36) g/kg/d Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Arm 3: Non-Māori women</p> <p>Baseline Protein Amount Median (IQR): 0.90 (0.73-1.13) g/kg/d Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p>	<p>Protein Assessment Method: Two times multiple pass 24-hour dietary recall. Nutrient intakes were calculated by coding all food and drinks using the New Zealand Food Composition Database.</p>	<p>Muscle Strength - Grip strength</p> <p>Measure/Method of Assessment: Measured using handgrip dynamometer</p>

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	<p>Rheumatoid arthritis: 19.1% Osteoarthritis: 25.0% Asthma or chronic lung disease: 38.8% Congestive heart failure: 36.1% Diabetes: 23.3% Medication use: NR Supplement use: NR Pregnant or lactating: NA</p> <p>Arm 3: Non-Māori women N: 183 % Female: 52% Mean Age (SD): 85.55 (0.51) y Race/ Ethnicity: NR Menopausal status: NR Obesity status: NR Mean BMI (SD): 26.81 (4.46) kg/m² Income level: NR Education level: NR Mean physical activity level (SD): 78.55 (53.49) PASE Health status/ Comorbidities: Rheumatoid arthritis: 13.1% Osteoarthritis: 50.3% Asthma or chronic lung disease: 29.5% Congestive heart failure: 17.5% Diabetes: 13.1% Medication use: NR Supplement use: NR Pregnant or lactating: NR</p> <p>Arm 4: Non-Māori men N: 169 % Female: NA Mean Age (SD): 85.56 (0.51) y Race/ Ethnicity: NR Menopausal status: NA</p>	<p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Arm 4: Non-Māori men</p> <p>Baseline Protein Amount Median (IQR): 0.97 (0.84-1.18) g/kg/d Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Protein Amount at the end of the study Median (IQR): NR Carbohydrate Median (IQR): NR Fat Median (IQR): NR</p> <p>Protein type/ source: Mixed</p> <p>Energy balance status: Eucaloric</p> <p>Study duration: 5 y</p>		

Study	Participants	Intervention (s) (Content)	Intervention (s) (Methods of assessment)	Outcome (Measures and methods of assessment)
	Obesity status: NR Mean BMI (SD): 26.66 (3.67) kg/m ² Income level: NR Education level: NR Mean physical activity level (SD): 94.37 (71.51) PASE Health status/ Comorbidities: Rheumatoid arthritis: 9.5% Osteoarthritis: 37.5% Asthma or chronic lung disease: 25.0% Congestive heart failure: 17.8% Diabetes: 13.6% Medication use: NR Supplement use: NR Pregnant or lactating: NR			

Abbreviations: aBW = adjusted body weight; ALM = Appendicular lean mass; ASM = Appendicular skeletal muscle mass; ASMI = Appendicular skeletal muscle mass index; BIA = bioelectrical impedance analysis; BMI = body mass index; COPD = chronic obstructive pulmonary disease; cpm = counts per minute d = days; DXA = Dual-energy x-ray absorptiometry; FFQ = Food frequency questionnaire; g = gram; GS = Grip strength; h = hour; HDI = human development index; IQR = inter quartile range; kg = kilograms; kg/m² = kilograms per meters squared; LC n-3 PUFA = long chain n-3 polyunsaturated fatty acids; m = meters; METs = metabolic equivalents; min = minutes; ml = milliliters; mg = milligrams; MRI = magnetic resonance imaging; NA = not applicable; NR = not reported; nmol/L = nanomoles per liter; NR = not reported; PASE = Physical Activity Score for the Elderly; PMID = PubMed Identification Number; PUFA = polyunsaturated fatty acids; RCT = randomized controlled trial; RM: Rep maximum; RoB = Risk of Bias; SD = standard deviation; SE = standard error; SPPB = Short Physical Performance Battery; TUG = Timed-Up-and-Go; WHI = Women's Health Initiative; wk = week; w/o = without; y = year

Note: *Studies overlap KQs

Appendix D. Summary of the Basic Characteristics of All Eligible Studies

Key Question 1. What is the association between dietary protein intake and risk of bone disease?

Overview

Studies were mainly non-RCTs, with prospective cohort study design (22 of 31 studies).¹⁰⁻³¹ The remaining studies (N=9) were randomized controlled trials (RCT).¹⁻⁹ We present information on all eligible studies in the evidence tables in Appendix C.

RCT

Table D1 summarizes the characteristics of the RCT literature set. We identified 8 unique studies from 8 unique publications that examined the association between dietary protein intake and risk of bone disease in adults.^{1-7,9} We identified one unique study that examined the association between dietary protein intake and risk of bone disease in children and adolescents.⁸ The earliest study that met the inclusion criteria was published in 2002.⁷ Studies were conducted in various countries, including three from the U.S.,^{2,5,6} two from Australia,^{4,9} two from Denmark,^{7,8} one from France,³ and one from Japan.¹ Adult study sample sizes ranged from 62² to 323.⁴ A large number of the adult studies (N=5) enrolled post-menopausal women^{1-4,9}. Overall, five studies had high risk of bias and were not included in the analytic set.^{1,2,4,6,9} Four studies (3 low risk and 1 moderate risk of bias) were included in the analytic set.^{3,5,7,8} One study had both low and high risk of bias based on the outcomes.⁵ We included that study in our analytic set and provide findings for the outcomes that had low risk of bias. We present information on the summary risk of bias assessments for all eligible studies in Appendix G.

Table D1. Basic characteristics of RCT literature set for risk of bone disease

Characteristic	Information (adults)	Information (children and adolescents)
Total studies	8 studies	1 study
U.S studies	3 studies	-
Non-U.S. studies	5 studies	1 study
Settings	Community dwelling: 6 studies Outpatient clinic: 1 study NR: 1 study	Community dwelling: 1 study
Study design	RCT (parallel): 8 studies	RCT (parallel): 1 study
Sex of study participants	Female only: 5 studies Female and Male: 3 studies	Female and Male: 1 study
Age range	31 to 74 years	6 to 8 years
Sample size range	62 to 323	200

Follow-up duration range	6 weeks – 2 years	24 weeks
Outcomes evaluated:	Bone Turnover Marker (Overall Turnover) – Osteocalcin: 4 studies Bone Formation Marker - BAP: 4 studies Bone Formation Marker - P1NP: 1 study Bone Resorption Marker - CTX: 2 studies Bone Resorption Marker – NTx: 1 study Bone Resorption Marker – TRAP: 1 study Bone Resorption Marker - Urinary excretion of deoxypyridinoline: 2 studies BMC of the Appendicular Skeleton (hip, total): 1 study BMC of the Axial Skeleton (lumbar spine): 3 studies BMD of the Appendicular Skeleton (femoral neck): 4 studies BMD of the Appendicular Skeleton (forearm, total): 2 studies BMD of the Appendicular Skeleton (hip, total): 4 studies BMD of the Axial Skeleton (lumbar spine): 2 studies Total Body/Whole Body BMC (total body): 3 studies Total Body/Whole Body BMD (total body): 4 studies Bone Geometry and Strength Indices - Femoral neck cross-sectional area: 1 study Bone Geometry and Strength Indices - Femoral neck buckling ratio: 1 study Bone Geometry and Strength Indices - Femoral neck polar CSMI (cross-sectional moment of inertia): 1 study	Bone Turnover Marker (Overall Turnover) – Osteocalcin: 1 study BMC of the Axial Skeleton (lumbar spine): 1 study BMD of the Axial Skeleton (lumbar spine): 1 study BMD of the Appendicular Skeleton z-score (lumbar spine): 1 study Bone Geometry and Strength Indices - Bone area (lumbar spine): 1 study
Menopausal status	Post-menopausal: 5 studies NR: 3 studies	N/A
Risk of bias of all eligible studies	Low: 2 studies* Moderate: 1 study High: 7 studies*	Low: 1 study
Analytic set	3 studies	1 study

Abbreviations: BAP = bone specific alkaline phosphatase; BMC = bone mineral content; BMD = bone mineral density; CTX = C-terminal peptide of collagen; NA = not applicable; NR = not reported; NTx = N-telopeptides of type I collagen; P1NP = procollagen type I N-terminal propeptide; RCT = randomized controlled trial; TRAP = 5b, tartrate resistant acid phosphatase, isoform 5; U.S. = United States

*: One study had both low and high risk of bias based on the outcomes.

Non-RCT

Table D2 summarizes the characteristics of the non-RCT literature set for adult studies. We identified 22 unique studies from 22 unique publications that examined the association between dietary protein intake and risk of bone disease in adults.¹⁰⁻³¹ The earliest study that met the inclusion criteria was published in 2000.¹⁶ Studies were conducted in various countries, including thirteen studies from the U.S.,^{10-12, 16, 17, 20, 22, 24, 26, 28-31} three from Australia,^{15, 18, 23} two from China,^{13, 21} one from France,¹⁴ one from Canada,¹⁹ one from Mexico,²⁷ and one from Japan.²⁵ Study adult sample sizes ranged from 560¹⁰ to 144,580.¹¹ A large number of the studies (N=11)

described participants as post-menopausal women.^{11, 14, 15, 19, 23, 25-30} Twenty-one studies had high risk or very high risk of bias and were not included in the analytic set.^{10-26, 28-31} One study with moderate risk of bias was included in the analytic set.²⁷ We present information on the summary of risk of bias assessments for all eligible studies in Appendix G.

Table D2. Basic Characteristics of non-RCT literature set for risk of bone disease: adults

Characteristic	Information
Total studies	22 studies
U.S studies	13 studies
Non-U.S. studies	9 studies
Settings	Community dwelling: 13 studies NR: 9 studies
Sex of study participants	Female only: 9 studies Male only: 2 studies Female and Male: 11 studies
Age range	24 to 78 years
Sample size range	560 to 144,580
Follow-up duration range	1-17 years
Outcomes evaluated:	BMD of the Appendicular Skeleton (femoral neck): 7 studies BMD of the Appendicular Skeleton (hip, total): 13 studies BMD of the Appendicular Skeleton (intertrochanter): 1 study BMD of the Appendicular Skeleton (trochanter): 3 studies BMD of the Appendicular Skeleton - mean percent bone loss (hip): 1 study BMD of the Appendicular Skeleton - mean percent bone loss (radius): 1 study BMD of the Axial Skeleton (lumbar spine): 8 studies BMD of the Axial Skeleton - mean percent bone loss (spine): 1 study Total Body/Whole Body BMC (total body): 1 study Total Body/Whole Body BMD (total body): 4 studies Osteoporotic Fractures and Fracture Risk - Fragility fracture (osteoporotic and low trauma fracture): 7 studies Osteoporotic Fractures and Fracture Risk - Hip fracture: 6 studies Osteoporotic Fractures and Fracture Risk - Spine fracture: 2 studies Osteoporotic Fractures and Fracture Risk - Forearm fracture: 1 study
Menopausal status	Pre-menopausal: 1 study Post-menopausal: 10 studies Pre and post-menopausal: 1 study NA: 2 studies NR: 8 studies
Risk of bias of all eligible studies	Moderate: 1 study High: 20 studies Very high: 1 study
Analytic set	1 study

Abbreviations: BMC = bone mineral content; BMD = bone mineral density; NA = not applicable; non-RCT = non-randomized controlled trial; NR = not reported; U.S. = United States

Key Question 2. What is the association between dietary protein intake and risk of kidney disease?

Overview

Studies were mainly non-RCTs, with prospective cohort study design (17 of 26 studies).³⁹⁻⁵⁵ The remaining studies used parallel (N=8)^{5, 6, 32-34, 36-38} and crossover RCT (N=1)³⁵ study designs. We present information on all eligible studies in the evidence tables in Appendix C.

RCT

Table D3 summarizes the characteristics of the RCT literature set. We identified 9 unique studies from 9 unique publications that examined the association between dietary protein intake and risk of kidney disease.^{5, 6, 32-38} The earliest study that met the inclusion criteria was published in 2008.³³ Studies were conducted in various countries, including five from the U.S.,^{5, 6, 33-35} one from Australia,³⁸ one from Ireland,³⁶ one from Germany,³² and one from China.³⁷ Studies had sample sizes ranging from 52³⁷ to 378.³⁴ Eight studies had high risk of bias and were not included in the analytic set.^{5, 6, 32-37} One study with moderate risk of bias was included in the analytic set.³⁸ We present information on the summary risk of bias assessments for all eligible studies in Appendix G.

Table D3. Basic characteristics of RCT literature set for risk of kidney disease

Characteristic	Information
Total studies	9 studies
U.S studies	5 studies
Non-U.S. studies	4 studies
Settings	Community dwelling: 7 studies Outpatient clinic: 1 study NR: 1 study
Study design	RCT (parallel): 8 studies RCT (cross over): 1 study
Sex of study participants	Male only: 1 study Female and Male: 8 studies
Age range	22 to >80 years (exact upper limit not reported)
Sample size range	52 to 378
Follow-up duration range	6 – 52 weeks
Outcomes evaluated:	Kidney Function – Serum creatinine: 5 studies Kidney Function – Creatinine clearance: 2 studies

	Kidney Function – eGFR: 4 studies Kidney Function – Blood urea nitrogen: 4 studies Kidney Function – Urinary urea nitrogen: 2 studies Kidney Function – Serum cystatin C: 2 studies Kidney Function – Serum Beta-2-microglobulin: 1 study Kidney Function – Urea clearance: 1 study Kidney stones – Urine calcium: 2 studies Proteinuria – Urinary albumin excretion: 1 study
Menopausal status	NA: 1 study NR: 8 studies
Risk of bias of all eligible studies	Moderate: 1 study High: 8 studies
Analytic set	1 study

Abbreviations: eGFR = estimated glomerular filtration rate; ESRD = end-stage renal disease; NA = not applicable; NR = not reported; RCT = randomized controlled trial; U.S. = United States

Non-RCT

Table D4 summarizes the characteristics of the non-RCT literature set. We identified 17 unique studies from 17 unique publications that examined the association between dietary protein intake and risk of kidney disease.³⁹⁻⁵⁵ The earliest study that met the inclusion criteria was published in 2003.⁴⁷ Studies were conducted in various countries, including five from the U.S.,^{43, 45, 47, 51, 52} three from Iran,^{39, 41, 55} two from South Korea,^{46, 49} two from Japan,^{48, 53} two from Netherlands,^{42, 44} one from Italy,⁴⁰ one from Singapore,⁵⁰ and one from China.⁵⁴ Studies had sample sizes ranging from 1624⁴⁷ to 127,220.⁵⁴ All seventeen studies had high risk or very high risk of bias and no non-RCT was included in the analytic set.³⁹⁻⁵⁵ We present information on the summary risk of bias assessments for all eligible studies in Appendix G.

Table D4. Basic characteristics of non-RCT literature set for risk of kidney disease

Characteristic	Information
Total studies	17 studies
U.S studies	5 studies
Non-U.S. studies	12 studies
Settings	Community dwelling: 17 studies
Sex of study participants	Female only: 1 study Female and Male: 16 studies
Age range	18 to 97 years
Sample size range	1624 to 127220
Follow-up duration range	3 – 25 years
Outcomes evaluated:	Kidney Function – Incident CKD: 6 studies Kidney Function – Incident ESRD: 2 studies Kidney Function – eGFR: 8 studies Kidney stones: 1 study

	Proteinuria – Presence of proteinuria: 1 study Hyperfiltration: 1 study
Menopausal status	NR: 17 studies
Risk of bias of all eligible studies	High: 12 studies Very high: 5 studies
Analytic set	0 studies

Abbreviations: eGFR = estimated glomerular filtration rate; ESRD = end stage renal disease; NA = not applicable; NR = not reported; non-RCT = non-randomized controlled; U.S. = United States

Key Question 3. What is the association between dietary protein intake and risk of sarcopenia?

Overview

Studies were mainly non-RCTs, with prospective cohort study design (19 of 35 studies).^{22, 23, 65-82} The remaining studies (N=16) used a parallel RCT study design.^{4, 5, 32, 33, 36-38, 56-64} We present information on all eligible studies in the evidence tables in Appendix C.

RCT

Table D5 summarizes the characteristics of the RCT literature set. We identified 16 unique studies from 16 unique publications that examined the association between dietary protein intake and risk of sarcopenia.^{4, 5, 32, 33, 36-38, 56-64} The earliest study that met the inclusion criteria was published in 2008.³³ Studies were conducted in various countries, including four from the U.S.,^{5, 33, 62, 63} three from Australia,^{4, 38, 64} one from New Zealand,⁵⁹ two from Germany,^{32, 57} two from China,^{37, 60} one from Netherlands,⁵⁶ one from Netherlands and Finland,⁶¹ one study from Iran,⁵⁸ and one from Ireland.³⁶ Studies had sample sizes ranging from 52⁶² to 323.⁴ A noticeable number of the studies (N=6) enrolled post-menopausal women.^{4, 56, 57, 62-64} Seven studies had a high risk of bias and were not included in the analytic set.^{4, 32, 33, 36, 37, 59, 63} Nine studies (seven low risk and two moderate risk of bias) were included in the analytic set.^{5, 38, 56-58, 60-62, 64} We present information on the summary risk of bias assessments for all eligible studies in Appendix G.

Table D5. Basic characteristics of RCT literature set for risk of sarcopenia

Characteristic	Information
Total studies	16 studies
U.S studies	4 studies
Non-U.S. studies	12 studies
Settings	Community dwelling: 14 studies Outpatient clinic: 1 study NR: 1 study
Study design	RCT (parallel): 16 studies

Sex of study participants	Female only: 7 studies Male only: 1 study Female and Male: 7 studies NR: 1 study
Age range	24 to 80 years
Sample size range	52 to 323
Follow-up duration range	11 weeks – 2 years
Outcomes evaluated:	Muscle mass – Appendicular skeletal muscle index (ASMi): 4 studies Muscle mass – Whole skeletal muscle mass estimated by BIA: 2 studies Muscle mass – Total lean body mass estimated by DXA: 6 studies Muscle mass – Total lean body mass estimated by BIA: 1 study Muscle mass – Total lean body mass NR: 1 study Muscle mass – Appendicular lean body mass / skeletal muscle mass estimated by DXA: 3 studies Muscle mass – Fat Free Mass estimated by DXA: 2 studies Muscle mass – Fat Free Mass estimated by BIA: 4 studies Physical performance – Timed Up-and-Go (TUG) [Timed: start in sitting position, get up and walk 3-meters, turn around come back and sit down]: 2 studies Physical performance – 6-meter timed walk or 6-meter walking speed: 1 study Physical performance – 6 min walking distance: 1 study Physical performance – 4 m walk gait speed: 1 study Physical performance – 40 m fast-paced walk test: 1 study Physical performance – 400m walk speed: 3 studies Physical performance – Gait speed assessment NR: 1 study Muscle Strength – Handgrip strength: 8 studies Muscle Strength – Leg/Knee extension (including 1-RM leg extension): 3 studies Muscle Strength – Knee flexion: 1 study Muscle Strength – 1-RM leg press: 1 study Muscle Strength – Sum 1-RM strength: 1 study Muscle Strength – Sum knee extension peak torque: 2 studies Muscle Strength – Sum knee flexion peak torque: 2 studies Muscle Strength – Chair stand test: 2 studies Muscle Strength – 5 times sit-to-stand, 5-time chair rise test: 2 studies Physical performance - SPPB (includes sit-to-stand test; 3- or 4-meter timed walk; balance): 5 studies
Menopausal status	Post-menopausal: 6 studies Pre-menopausal: 1 study NA: 1 study NR: 8 studies
Risk of bias of all eligible studies	Low: 7 studies Moderate: 2 studies High: 7 studies
Analytic set	9 studies

Abbreviations: BIA = bioelectrical impedance analysis; DXA = dual-energy x-ray absorptiometry; m = meter; NA = not applicable; NR = not reported; RCT = randomized controlled trial; RM = repetition maximum; SPPB = Short physical performance battery; U.S. United States

Non-RCT

Table D6 summarizes the characteristics of the non-RCT literature set. We identified 20 articles reporting on 19 unique studies that examined the association between dietary protein intake and risk of sarcopenia.^{22, 23, 65-82} The earliest study that met the inclusion criteria was published in 2008.⁷² Studies were conducted in various countries, including four from the U.S.,^{22, 65, 68, 72} three from Canada,^{69, 71, 79} two from the UK,^{70, 77} two from Korea,^{74, 81} two from Australia,^{23, 80} two from China,^{66, 67} one from Finland,⁷³ one from Japan,⁷⁸ one from New Zealand,⁸² and one from multiple countries.⁷⁶ Studies had sample sizes ranging from 172⁷⁹ to 134,961.⁶⁵ A large number of the studies described participants as post-menopausal women (N=9).^{23, 65, 66, 68, 70, 72, 73, 75, 78} All nineteen studies had a high risk or very high risk of bias and no non-RCT was included in the analytic set.^{22, 23, 65-82} We present information on the summary risk of bias assessments for all eligible studies in Appendix G.

Table D6. Basic characteristics of non-RCT literature set for risk of sarcopenia

Characteristic	Information
Total studies	19 studies
U.S studies	4 studies
Non-U.S. studies	15 studies
Settings	Community dwelling: 13 studies Mixed: 1 study NR: 5 studies
Sex of study participants	Female only: 3 studies Male only: 0 studies Female and Male: 16 studies
Age range	36 to 86 years
Sample size range	172 to 134,961
Follow-up duration range	2 – 16 years
Outcomes evaluated:	Muscle mass – Appendicular skeletal muscle mass index (ASMI): 1 study Muscle mass – Skeletal muscle index (SMI): 1 study Muscle mass – Total lean body mass estimated by DXA: 5 studies Muscle mass – Total lean body mass estimated by BIA: 1 study Muscle mass – Appendicular lean body mass/ skeletal muscle mass estimated by DXA: 8 studies Physical performance – Timed Up-and-Go (TUG) [Timed: start in sitting position, get up and walk 3-meters, turn around come back and sit down]: 2 studies Physical performance – 6-meter timed walk or 6-meter walking speed: 2 studies Physical performance – Walk a 20-m course at their usual walking pace: 1 study Physical performance – Narrow walk speed: 1 study Physical performance – Walking speed: 1 study Muscle Strength – Handgrip strength: 9 studies Muscle Strength – Leg/Knee extension (including 1-RM leg extension): 4 studies Muscle Strength – Chair stand test: 4 studies
Menopausal status	Post-menopausal: 9 studies Pre and post-menopausal: 2 study

	NR: 8 studies
Risk of bias of all eligible studies	High: 17 studies Very high: 2 studies
Analytic set	0 studies

Abbreviations: BIA = bioelectrical impedance analysis; CT = computerized tomography; DXA = dual-energy x-ray absorptiometry; MRI = magnetic resonance imaging; NA = not applicable; non-RCT = non-randomized controlled trial; NR = not reported; RM = repetition maximum; U.S. = United States

Appendix E. Results Tables for All Analyzed Studies

Table E1. Bone Disease RCT: Bone Turnover Marker-Overall Turnover (Adults)

Study	Statistics/Confounders adjusted for	Osteocalcin
PMID: 22357739 Author: Bonjour Study year: 2012 ³	Statistics: Pearson correlation coefficient Confounders adjusted for: None	<p>Intervention: Treated group (test food - 13.8 g protein)</p> <p>Baseline: n analyzed: 36 M (SD): 25.9 (9.7) mg/L</p> <p>Follow-up (6 weeks): n analyzed: 36 Change in Osteocalcin M (SD): -0.39 (3.6) mg/L</p> <p>Comparator: Usual diet</p> <p>Baseline: n analyzed: 35 M (SD): 26.9 (9.6) mg/L</p> <p>Follow-up (6 weeks): n analyzed: 35 Change in Osteocalcin M (SD): 0.77 (3.4)</p> <p>Between group comparison and p-value: Not statistically difference from comparator (p>0.05)</p>

Abbreviations: g = gram; M = mean; mg/L = milligrams per liter; n = number analyzed; PMID = PubMed Identification Number; RCT = randomized controlled trial; SD = standard deviation

Table E2. Bone Disease RCT: Bone Resorption Markers Outcome (Adults)

Study	Statistics/Confounders adjusted for	CTX	TRAP
PMID: 22357739 Author: Bonjour Study year: 2012 ³	Statistics: Pearson correlation coefficient Confounders adjusted for: None	<p>Intervention: Treated group (test food - 13.8 g protein)</p> <p>Baseline: n analyzed: 36 M (SD) 3.56 (1.6) nmol/L</p>	<p>Intervention: Treated group (test food - 13.8 g protein)</p> <p>Baseline: n analyzed: 36 M (SD) 5.49 (1.42) U/L</p>

Study	Statistics/Confounders adjusted for	CTX	TRAP
		<p>Follow-up (6 weeks): n analyzed: 36 (Change in CTX): M (SD) -0.18 (0.70) nmol/L</p> <p>Comparator: Usual diet</p> <p>Baseline: n analyzed: 35 M (SD) 3.56 (1.58) nmol/L</p> <p>Follow up (6 weeks): n analyzed: 35 (Change in CTX) M (SD): 0.06 (0.85) nmol/L</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05) P=0.23</p>	<p>Follow up (6 weeks): n analyzed: 36 (Change in TRAP): M (SD) -0.64 (0.56) U/L</p> <p>Comparator: Usual diet</p> <p>Baseline: n analyzed: 35 M (SD) 5.35 (1.38) U/L</p> <p>Follow up (6 weeks): n analyzed: 35 (Change in TRAP): M (SD) -0.34 (0.59) U/L</p> <p>Between group comparison and p-value: Statistically different from comparator (p<0.05) P = 0.011</p>

Abbreviations: CTX = carboxy terminal crosslinked telopeptide of type I collagen; g = gram; M = mean; n = number analyzed; nmol/L = nanomols per liter; PMID = PubMed Identification Number; RCT = randomized controlled trial; SD = standard deviation; TRAP = tartrate resistant acid phosphatase; U/L = Units per Liter;

Table E3. Bone Disease RCT: Bone Formation Markers Outcome (Adults)

Study	Statistics/Confounders adjusted for	BAP	P1NP
PMID: 22357739 Author: Bonjour Study year: 2012 ³	<p>Statistics: Pearson correlation coefficient</p> <p>Confounders adjusted for: None</p>	<p>Intervention: Treated group (test food - 13.8 g protein)</p> <p>Baseline n analyzed: 36 M (SD) 11.3 (3.8) mg/L</p> <p>Follow-up (6 weeks): n analyzed: 36 M (SD) -1.2 (1.8) mg/L</p> <p>Comparator: Usual diet</p> <p>Baseline: n analyzed: 35 M (SD) 10.8 (3.2) mg/L</p>	<p>Intervention: Treated group (test food - 13.8 g protein)</p> <p>Baseline n analyzed: 36 M (SD) 52.0 (19.7) mg/L</p> <p>Follow-up (6 weeks): n analyzed: 36 M (SD) 0.25 (9.3) mg/L</p> <p>Comparator: Usual diet</p> <p>Baseline: n analyzed: 35 M (SD) 54.2 (20.3) mg/L</p>

Study	Statistics/Confounders adjusted for	BAP	P1NP
		Follow-Up (6 weeks): n analyzed: 35 M (SD) -0.9 (1.2) mg/L Between group comparison and p-value: Not statistically different from comparator (p>0.05)	Follow-up (6 weeks): n analyzed: 35 M (SD) 2.8 (10.8) mg/L Between group comparison and p-value: Not statistically different from comparator (p>0.05)

Abbreviations: BAP = bone specific alkaline phosphatase; g = gram; M = mean; mg/L = milligrams per liter; n = number analyzed; P1NP = procollagen type 1 N-terminal; PMID = PubMed Identification Number; RCT = randomized controlled trial; SD = standard deviation

Table E4. Bone Disease RCT: BMD of the Axial Skeleton Outcome (Adults)

Study	Statistics/Confounders adjusted for	Lumbar spine BMD
PMID: 25844619 Author: Kerstetter Study year: 2015 ⁵	Statistics: General linear mixed-models analysis Confounders adjusted for: gender, age, body composition, and baseline BMD, measures of bone turnover, 25(OH)D, eGFR, and 24-hour urinary urea	Intervention: High Protein (45g whey protein supplement isolate) Baseline: n analyzed: 105 M (SD) 1.09 (0.01) g/cm ² Follow-up (18 months): n analyzed: 92 M (SD) 1.10 (0.01) g/cm ² Comparator: Low Protein (carbohydrate (isocaloric maltodextrin control supplement) Baseline: n analyzed: 102 M (SD) 1.10 (0.01) g/cm ² Follow-up (18 months): n analyzed: 79 M (SD) 1.11 (0.02) g/cm ² Between group comparison and p-value: Not statistically different from comparator (p>0.05)
PMID: 12055318 Author: Skov Study year: 2002 ⁷	Statistics: Mixed Regression Model [interaction] Confounders adjusted for: Dietary calcium intake, changes in fat mass	Intervention: High protein diet (protein - 25% of total energy) Baseline:

Study	Statistics/Confounders adjusted for	Lumbar spine BMD
		<p>n analyzed: 25 M (SEM) 1.03 (0.02) g/cm²</p> <p>Follow-up (6 months): n analyzed: 25 M (SEM) 1.04 (0.02) g/cm²</p> <p>Comparator: Low protein diet (protein - 12% of total energy)</p> <p>Baseline: n analyzed: 25 M (SEM) 1.17 (0.01) g/cm²</p> <p>Follow up (6 months): n analyzed: 25 M (SEM) 1.01 (0.03) g/cm²</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05)</p>

Abbreviations: 25(OH)D = 25-hydroxyvitamin D; BMD = bone mineral density; eGFR = estimated glomerular filtration rate; g/cm² = grams per centimeter squared; M = mean; n = number analyzed; PMID = PubMed Identification Number; RCT = randomized controlled trial; SD = standard deviation; SEM = standard error of the mean

Note: *Study overlaps KQs

Table E5. Bone Disease RCT: BMD of the Appendicular Skeleton Outcome (Adults)

Study	Statistics/Confounders adjusted for	Total hip BMD	Femoral neck BMD
PMID: 25844619 Author: Kerstetter Study year: 2015 * ⁵	Statistics: General linear mixed-models analysis Confounders adjusted for: gender, age, body composition, and baseline BMD, measures of bone turnover, 25(OH)D, eGFR, and 24-hour urinary urea	<p>Intervention: High Protein (45g whey protein supplement isolate)</p> <p>Baseline: n analyzed: 106 LSM (SEM) 0.89 (0.01) g/cm²</p> <p>Follow up (18 months): n analyzed: 92 LSM (SEM) 0.88 (0.01) g/cm²</p>	<p>Intervention: High Protein (45g whey protein supplement isolate)</p> <p>Baseline: n analyzed: 106 LSM (SEM) 0.81 (0.01) g/cm²</p> <p>Follow up (18 months): n analyzed: 92 LSM (SEM) 0.80 (0.01) g/cm²</p>

Study	Statistics/Confounders adjusted for	Total hip BMD	Femoral neck BMD
		<p>Comparator: Low Protein (carbohydrate (isocaloric maltodextrin control supplement)</p> <p>Baseline: n analyzed: 102 LSM (SEM) 0.90 (0.01) g/cm²</p> <p>Follow up (18 months): n analyzed: 79 LSM (SEM) 0.89 (0.01) g/cm²</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05),</p>	<p>Comparator: Low Protein (carbohydrate (isocaloric maltodextrin control supplement)</p> <p>Baseline: n analyzed: 102 LSM (SEM) 0.82 (0.01) g/cm²</p> <p>Follow up (18 months): n analyzed: 79 LSM (SEM) 0.82 (0.01) g/cm²</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05),</p>

Abbreviations: BMD = bone mineral density; CI = confidence interval; DXA = dual x-ray absorptiometry; g/cm² = grams per centimeter squared; LSM = least square mean; n = number analyzed; PMID = PubMed Identification Number; SEM = standard error of the mean

Note: *Study overlaps KQs

Table E6. Bone Disease RCT: Total Body BMD and BMC Outcome (Adults)

Study	Statistics /Confounders adjusted for	Total body BMC	Total body BMD
PMID: 12055318 Author: Skov Study year: 2002 ⁷	<p>Statistics: Mixed Regression Model</p> <p>Confounders adjusted for: Dietary calcium intake, changes in fat mass</p>	<p>Intervention: High Protein (45g whey protein supplement isolate)</p> <p>Baseline: n analyzed: 25 M (SEM) 2828 (71) g</p> <p>Follow up (6 months): n analyzed: 25 M (SEM) 2713 (75) g</p> <p>Comparator: Low protein diet (protein - 12% of total energy)</p> <p>Baseline: n analyzed: 25 M (SEM) 2760 (72) g</p>	<p>Intervention: High Protein (45g whey protein supplement isolate)</p> <p>Baseline: n analyzed: 25 M (SEM) 1.17 (0.01) g/cm²</p> <p>Follow up (6 months): n analyzed: 25 M (SEM) 1.17 (0.01) g/cm²</p> <p>Comparator: Low protein diet (protein - 12% of total energy)</p> <p>Baseline:</p>

Study	Statistics /Confounders adjusted for	Total body BMC	Total body BMD
		Follow up (6 months): n analyzed: 25 M (SEM) 2660 (75) g Between group comparison and p-value: Statistical difference from comparator(p<0.05)	n analyzed: 25 M (SEM) 1.18 (0.01) g/cm ² Follow up (6 months): n analyzed: 25 M (SEM) 1.17 (0.01) g/cm ² Between group comparison and p-value: Not statistical different from comparator (p>0.05)

Abbreviations: BMC = bone mineral content; BMD = bone mineral density; DXA = dual x-ray absorptiometry; g = grams; g/cm² = grams per centimeter squared; M = mean; n = number analyzed; PMID = PubMed Identification Number; RCT = randomized controlled trial; SEM = standard error of the mean

Table E7. Bone Disease Non-RCT: BMD of the Axial Skeleton Outcome (Adults)

Study	Statistics/ Confounders adjusted for	Lumbar spine BMD
PMID: 33847345 Author: Rivera-Paredes Study year: 2021 ²⁷	Statistics: Hybrid mixed-effects regression models Confounders adjusted for: energy intake (nutrients adjusted by the residual method) adjusted for: age (years), body mass index (kg/m ²), alcohol consumption (g/day), smoking status (non-smoker, smoker, ex-smoker) and leisure time physical activity (min/day)	Arm: Whole cohort Baseline: n Analyzed: NR* Mean (SD): 1.035 (0.171) g/cm ² Follow-up (6.4 years): n Analyzed: 317 Mean (SD): 0.999 (0.893) g/cm ² Comparator: NA Not statistically different between subject associations (β, beta coefficient): 0.065 (95% CI -0.063,0.194) (p>0.05) P = 0.32

Abbreviations: BMD = bone mineral density; g/cm² = grams per square centimeter; HR = hazard ratio; n = number analyzed; non-RCT = non-randomized controlled trial; NR = not reported; OR = odds ratio; PMID = PubMed Identification Number; RoB = Risk of Bias; RR = relative risk; SD = standard deviation

Note: *42% of the total postmenopausal women evaluated in the second wave of the study

Table E8. Bone Disease Non-RCT: BMD of the Appendicular Skeleton Outcome (Adults)

Study	Statistics/Confounders adjusted for	Total hip BMD	Femoral neck BMD
PMID: 33847345 Author: Rivera-Paredes Study year: 2021 ²⁷	Statistics: Hybrid mixed-effects regression models Confounders adjusted for: energy intake (nutrients adjusted by the residual method) adjusted for: age (years), body mass index (kg/m ²), alcohol consumption (g/day), smoking status (non-smoker, smoker, ex-smoker) and leisure time physical activity (min/day)	Arm: Whole cohort Baseline: n Analyzed: NR* Mean (SD): 0.959 (0.140) g/cm ² Follow-up (6.4 years): n Analyzed: 317 Mean (SD): 0.917 (0.137) g/cm ² Comparator: NA Not statistically different between subject associations (β , beta coefficient): 0.101 (95% CI -0.017,0.219) (p>0.05) P =0.09	Arm: Whole cohort Baseline: n Analyzed: NR* Mean (SD): 0.921 (0.135) g/cm ² Follow-up (6.4 years): n Analyzed: 317 Mean (SD): 0.873 (0.127) g/cm ² Comparator: NA Statistical difference between subject associations (β , beta coefficient): 0.124 (95% CI 0.010, 0.237). (p<0.05) P = 0.03

Abbreviations: BMD = bone mineral density; CI = confidence interval; g/cm² = grams per square centimeter; HR = hazard ratio; n = number analyzed; NA = not applicable; non-RCT = non-randomized controlled trial; NR = not reported; OR = odds ratio; PMID = PubMed Identification Number; RoB = Risk of Bias; RR = relative risk; SD = standard deviation

Note: *42% of the total postmenopausal women evaluated in the second wave of the study

Table E9. Bone Disease RCT: Bone Turnover Marker-Overall Turnover Outcome (Children and Adolescents)

Study	Statistics /Confounders adjusted for	Osteocalcin
PMID: 34581765 Author: Stounbjerg Study year: 2021 ⁸	Statistics: 2-way ANCOVA Confounders adjusted for: gender, age, puberty, BMI and Vitamin D tablet group	Intervention 1: Placebo-HP (placebo plus drained low-fat yogurt with a high protein content of 9-11 g protein/100 g) Baseline: n analyzed: 33-34 M (SD): 38.3 (9.1) μ g/L Follow up (24 weeks): n analyzed: 33-34 M (SD): 38.3 (9.1) μ g/L

Study	Statistics /Confounders adjusted for	Osteocalcin
		<p>Intervention 2: Vitamin D-HP (vitamin D plus drained low-fat yogurt with a high protein content of 9-11 g protein/100 g)</p> <p>Baseline: n analyzed: 39-41 M (SD): 37.1 (10.8) µg/L</p> <p>Follow up (24 weeks): n analyzed: 39-41 M (SD): 38.2 (10.0) µg/L</p> <p>Comparator 1: Placebo-NP (placebo plus regular yogurt with a normal protein content of 3.0-3.9 g protein/100 g)</p> <p>Baseline: n analyzed: 36 M (SD): 38.1 (11.9) µg/L</p> <p>Follow up (24 weeks): n analyzed: 36 M (SD): 5.3 (8.5) µg/L</p> <p>Comparator 2: Vitamin D-NP (vitamin D plus regular yogurt with a normal protein content of 3.0-3.9 g protein/100 g)</p> <p>Baseline: n analyzed: 38-41 M (SD) 37.1 (9.5) µg/L</p> <p>Follow up (24 weeks): n analyzed: 38-41 M (SD): 39.8 (9.8) µg/L</p>

Study	Statistics /Confounders adjusted for	Osteocalcin
		Between group comparison and p-value: Statistically different from comparator P = 0.017

Abbreviations: ANCOVA = analysis of covariance; g = gram; HP = normal protein; M = mean; n = number analyzed; NP = normal protein; PMID = PubMed Identification Number; RCT = randomized controlled trial; SD = standard deviation; µg/L = micro grams per liter

Note: The 2 high protein intake arms were combined by the study authors for the analyses of their study findings; and the 2 normal protein intake arms findings reports were also combined by the study authors for the analyses of their study findings

Table E10. Bone Disease RCT: BMD and BMC of the Axial Skeleton Outcome (Children and Adolescents)

Study	Statistics/Confounders adjusted for	Lumbar spine (L1–L4) BMD	Lumbar spine (L1–L4) zscore BMD	Lumbar spine (L1–L4) BMC
PMID: 34581765 Author: Stounbjerg Study year: 2021⁸	Statistics: 2-way ANCOVA Confounders adjusted for: gender, age, puberty, BMI and Vitamin D tablet group	Intervention 1: Placebo-HP (placebo plus drained low-fat yogurt with a high protein content of 9-11 g protein/100 g) Baseline: n analyzed: 45 M (SD): 0.681 (0.074) g/cm ² Follow up (24 weeks): n analyzed: 45 M (SD): 0.681 (0.074) g/cm ² Intervention 2: Vitamin D-HP (vitamin D plus drained low-fat yogurt with a high protein content of 9-11 g protein/100 g) Baseline: n analyzed: 49 M (SD): 0.682 (0.084) g/cm ² Follow up (24 weeks): n analyzed: 49 M (SD): 0.692 (0.082) g/cm ² Comparator 1: Placebo-NP (placebo plus regular yogurt with a normal protein	Intervention 1: Placebo-HP (placebo plus drained low-fat yogurt with a high protein content of 9-11 g protein/100 g) Baseline: n analyzed: 45 M (SD): 0.056 (0.807) Follow up (24 weeks): n analyzed: 45 M (SD): 0.056 (0.807) Intervention 2: Vitamin D-HP (vitamin D plus drained low-fat yogurt with a high protein content of 9-11 g protein/100 g) Baseline: n analyzed: 49 M (SD): 0.077 (0.955) Follow up (24 weeks): n analyzed: 49 M (SD): 0.066 (0.908) Comparator 1: Placebo-NP (placebo plus regular yogurt with a normal protein	Intervention 1: Placebo-HP (placebo plus drained low-fat yogurt with a high protein content of 9-11 g protein/100 g) Baseline: N analyzed: 45 M (SD): 21.5 (4.4) g Follow up (24 weeks): n analyzed: 45 M (SD): 21.5 (4.4) g Intervention 2: Vitamin D-HP (vitamin D plus drained low-fat yogurt with a high protein content of 9-11 g protein/100 g) Baseline: n analyzed: 49 M (SD): 21.8 (4.2) g Follow up (24 weeks): n analyzed: 49 M (SD): 23.2 (4.3) g Comparator 1: Placebo-NP (placebo plus regular yogurt with a normal protein

Study	Statistics/Confounders adjusted for	Lumbar spine (L1–L4) BMD	Lumbar spine (L1–L4) zscore BMD	Lumbar spine (L1–L4) BMC
		<p>content of 3.0-3.9 g protein/100 g</p> <p>Baseline: n analyzed: 44 M (SD): 0.691 (0.078) g/cm²</p> <p>Follow up (24 weeks): n analyzed: 44 M (SD): 0.702 (0.086) g/cm²</p> <p>Comparator 2: Vitamin D-NP (vitamin D plus regular yogurt with a normal protein content of 3.0-3.9 g protein/100 g)</p> <p>Baseline: n analyzed: 46 M (SD): 0.679 (0.074) g/cm²</p> <p>Follow up (24 weeks): n analyzed: 46 M (SD): 0.695 (0.078) g/cm²</p> <p>Between group comparison and p-value: Statistically different from comparator P = 0.027</p>	<p>content of 3.0-3.9 g protein/100 g</p> <p>Baseline: n analyzed: 44 M (SD): 0.152 (0.918)</p> <p>Follow up (24 weeks): n analyzed: 44 M (SD): 0.145 (0.980)</p> <p>Comparator 2: Vitamin D-NP (vitamin D plus regular yogurt with a normal protein content of 3.0-3.9 g protein/100 g)</p> <p>Baseline: n analyzed: 46 M (SD): 0.022 (0.836)</p> <p>Follow up (24 weeks): n analyzed: 46 M (SD): 0.073 (0.852)</p> <p>Between group comparison and p-value: Statistically different from comparator P = 0.026</p>	<p>content of 3.0-3.9 g protein/100 g</p> <p>Baseline: n analyzed: 44 M (SD): 22.4 (4.6) g</p> <p>Follow up (24 weeks): n analyzed: 44 M (SD): 23.8 (5.2) g</p> <p>Comparator 2: Vitamin D-NP (vitamin D plus regular yogurt with a normal protein content of 3.0-3.9 g protein/100 g)</p> <p>Baseline: n analyzed: 46 M (SD): 22.3 (4.1) g</p> <p>Follow up (24 weeks): n analyzed: 46 M (SD): 23.6 (4.5) g</p> <p>Between group comparison and p-value: Not statistically different from comparator P = 0.944</p>

Abbreviations: ANCOVA = analysis of covariance; BMC = bone mineral content; BMD = bone mineral density; g = grams; g/cm² = grams per centimeter squared; HP = high protein; M = mean; n = number analyzed; NP = normal protein; PMID = PubMed Identification Number; RCT = randomized controlled trial; SD = standard deviation

Note: The 2 high protein intake arms were combined by the study authors for the analyses of their study findings; and the 2 normal protein intake arms findings reports were also combined by the study authors for the analyses of their study findings.

Table E11. Bone Disease RCT: Bone Geometry and Strength Indices Outcome (Children and Adolescents)

Study	Statistics /Confounders adjusted for	BA lumbar spine (L1–L4)
PMID: 34581765 Author: Stounbjerg Study year: 2021 ⁸	Statistics 2-way ANCOVA	Intervention 1: Placebo-HP (placebo plus drained low-fat yogurt with a high protein content of 9-11 g protein/100 g)

Study	Statistics /Confounders adjusted for	BA lumbar spine (L1–L4)
	<p>Confounders adjusted for: gender, age, puberty, BMI and Vitamin D tablet group</p>	<p>Baseline: n analyzed: 45 M (SD): 1.3 (4.2) cm²</p> <p>Follow up (24 weeks): n analyzed: 45 M (SD): 1.3 (4.2) cm²</p> <p>Intervention 2: Vitamin D-HP (vitamin D plus drained low-fat yogurt with a high protein content of 9-11 g protein/100 g)</p> <p>Baseline: n analyzed: 49 M (SD): 31.9 (3.7) cm²</p> <p>Follow up (24 weeks): n analyzed: 49 M (SD): 33.3 (3.8) cm²</p> <p>Comparator 1: Placebo-NP (placebo plus regular yogurt with a normal protein content of 3.0-3.9 g protein/100 g)</p> <p>Baseline: n analyzed: 44 Mean (SD): 32.2 (3.8) cm²</p> <p>Follow up (24 weeks): n analyzed: 44 M (SD): 33.8 (4.3) cm²</p> <p>Comparator 2: Vitamin D-NP (vitamin D plus regular yogurt with a normal protein content of 3.0-3.9 g protein/100 g)</p> <p>Baseline: n analyzed: 46 M (SD): 32.7 (3.4) cm²</p> <p>Follow up (24 weeks): n analyzed: 46 M (SD): 33.8 (3.6) cm²</p> <p>Between group comparison and p-value: Not statistically different from comparator P = 0.133</p>

Abbreviations: BA = bone area; BMI = body mass index; n = number analyzed; ANCOVA = analysis of covariance; cm² = centimeter squared; g = gram; HP = high protein; M = mean; NP = normal protein; PMID = PubMed Identification Number; SD = standard deviation

Note: The 2 high protein intake arms were combined by the study authors for the analyses of their study findings; and the 2 normal protein intake arms findings reports were also combined by the study authors for the analyses of their study findings.

Table E12. Kidney Disease RCT: Kidney Function Outcome

Study	Statistics/Confounders adjusted for	Creatinine clearance
PMID: 22406907 Author Wycherley Study Year 2012 ^{*38}	Statistics: Intention-to-treat - maximal likelihood mixed model analysis with fixed and random effects Confounders adjusted for: NR	Intervention: High Protein (35% energy from protein) Baseline: n Analyzed: 58** Mean (SD): NR Follow up: n Analyzed: 58** Mean (SD): NR Comparator: Low protein (high carbohydrate - 17% energy from protein) Baseline: n Analyzed: 62** Mean (SD): NR Follow up: n Analyzed: 62** Mean (SD): NR Between group comparison and p-value Not statistically different from comparator P = 0.55

Abbreviations: n = number analyzed; NR = not reported; PMID = PubMed Identification Number; SD = standard deviation

Note: *Study overlaps KQs; ** Baseline characteristics were presented for participants who completed the 52-week intervention; but intention-to-treat evaluation was conducted for the full sample.

Table E13. Sarcopenia RCT: Muscle mass Outcome

Study	Statistics/ Confounders adjusted for	Total body lean mass	Appendicular lean mass/ skeletal muscle mass	Appendicular skeletal muscle index (ASMi)	Whole skeletal Muscle Mass	Fat free mass (FFM)
PMID: 26471344 Author: Backx Year: 2016 ⁵⁶	Statistics: ANCOVA Cofounders adjusted for:	Intervention: High protein diet (contain 1.7 g of protein/kg/day) Baseline: n Analyzed: 31	Intervention: High protein diet (contain 1.7 g of protein/kg/day) Baseline: n Analyzed: 31	-	-	-

Study	Statistics/ Confounders adjusted for	Total body lean mass	Appendicular lean mass/ skeletal muscle mass	Appendicular skeletal muscle index (ASMi)	Whole skeletal Muscle Mass	Fat free mass (FFM)
	BMI, gender, age, fasting glucose	<p>Mean (SD): 54.8 (12.2) kg</p> <p>Follow-up (12 weeks): N Analyzed: NR Mean (SD): 53.1 (11.4) kg</p> <p>Comparator: Normal Protein diet (contain 0.9 g protein/kg/day) Baseline: n Analyzed: 30 Mean (SD): 54.5 (9.3) kg</p> <p>Follow-up (12 weeks): n Analyzed: NR Mean (SD): 52.4 (9.1) kg</p> <p>Between group comparison and p-value: Not statistically different from comparator P = 0.219</p>	<p>Mean (SD): 23.8 (5.5) kg</p> <p>Follow-up (12 weeks): N Analyzed: NR Mean (SD): 23.1 (5.4) kg</p> <p>Comparator: Normal Protein diet (contain 0.9 g protein/kg/day) Baseline: n Analyzed: 30 Mean (SD): 23.8 (4.8) kg</p> <p>Follow-up (12 weeks): n Analyzed: NR Mean (SD): 22.8 (4.6) kg</p> <p>Between group comparison and p-value: Not statistically different from comparator P = 0.122</p>			
PMID: 33975325 Author: Englert Year: 2021 ⁵⁷	Statistics: T- test Confounders adjusted for: NR	-	-	-	-	<p>Intervention: High Protein (1.5 g/kg body weight/day) Baseline: n Analyzed: 27 Mean (SD): 46.8 (6.9) kg</p> <p>Follow-up (12 weeks): n Analyzed: 27 Mean (SD) (Change at 12 weeks): -0.9 (1.1) kg</p>

Study	Statistics/ Confounders adjusted for	Total body lean mass	Appendicular lean mass/ skeletal muscle mass	Appendicular skeletal muscle index (ASMi)	Whole skeletal Muscle Mass	Fat free mass (FFM)
						<p>Comparator: Normal Protein (0.8 g/kg body weight/day) Baseline: n Analyzed: 27 Mean (SD): 46.7 (5.0) kg</p> <p>Follow-up (12 weeks) n Analyzed: 27 Mean (SD) (Change at 12 weeks): -1.0 (1.3) kg</p> <p>Between group comparison and p- value: Not statistically different from comparator P = 0.575</p>
PMID: 34208986 Author: Haghighat Year: 2021 ⁵⁸	Statistics: ANCOVA Confounders adjusted for: NR	-	-	-	<p>Intervention: High protein (high protein snack (50g of soybeans, protein: 18.2 g)) Baseline: n Analyzed: 60 NR</p> <p>Follow-up (6 months): n Analyzed: 52 Mean increase 1.2 kg (95% CI=1.5 to 1)</p>	-

Study	Statistics/ Confounders adjusted for	Total body lean mass	Appendicular lean mass/ skeletal muscle mass	Appendicular skeletal muscle index (ASMi)	Whole skeletal Muscle Mass	Fat free mass (FFM)
					<p>Comparator: Low protein (~3.5 servings of fruit, protein: <2 g) Baseline: n Analyzed: NR NR</p> <p>Follow-up (6 months): n Analyzed: 55 Mean increase 0.3 kg (95% CI=0.7 to 0.02)</p> <p>Between group comparison and p-value: Statistically different from comparator (p<0.001)</p>	
PMID: 25844619 Author: Kerstetter Year: 2015 ⁵	<p>Statistics: General linear mixed-models analysis</p> <p>Confounders adjusted for: gender, age, body composition, and baseline BMD, measures of bone turnover, 25(OH)D, eGFR, and 24-</p>	<p>Intervention: High Protein (45g whey protein supplement isolate: 40 g of protein) Baseline: n Analyzed: 105 Mean (SEM): 42.6 (0.8) kg</p> <p>Follow-up (18 months): n Analyzed: 105 Mean (SEM): 42.6 (0.8) kg</p>	-	-	-	-

Study	Statistics/ Confounders adjusted for	Total body lean mass	Appendicular lean mass/ skeletal muscle mass	Appendicular skeletal muscle index (ASMi)	Whole skeletal Muscle Mass	Fat free mass (FFM)
	hour urinary urea	<p>Comparator: Low Protein (carbohydrate - isocaloric maltodextrin control supplement) Baseline: n Analyzed: 102 Mean (SEM): 42.0 (0.8) kg</p> <p>Follow-up (18 months): n Analyzed: 102 Mean (SEM): 41.5 (0.8) kg</p> <p>Between group comparison and p-value: Not statistically different from comparator P = 0.069)</p>				
PMID: 33612439 Author: Li Year: 2021 ⁶⁰	<p>Statistics: ANCOVA</p> <p>Confounders adjusted for: Sex, age, height, physical activity level, total dietary energy intake</p>	<p>Intervention 1: Whey Protein (whey protein blended supplement twice daily: 7.98 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 34.96 (6.75) kg</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 35.13 (6.4) kg</p> <p>Intervention 2: Soy protein (soy protein blended supplement twice daily: 8.80 g protein per supplement) Baseline: n Analyzed: 31</p>	<p>Intervention 1: Whey Protein (whey protein blended supplement twice daily: 7.98 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 14.47 (3.34) kg</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 14.62 (3.10) kg</p> <p>Intervention 2: Soy protein (soy protein blended supplement twice daily: 8.80 g protein per supplement) Baseline: n Analyzed: 31</p>	<p>Intervention 1: Whey Protein (whey protein blended supplement twice daily: 7.98 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 5.70 (0.92) kg/m²</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 5.76 (0.81) kg/m²</p> <p>Intervention 2: Soy protein (soy protein blended supplement twice daily: 8.80 g protein per supplement) Baseline:</p>	-	-

Study	Statistics/ Confounders adjusted for	Total body lean mass	Appendicular lean mass/ skeletal muscle mass	Appendicular skeletal muscle index (ASMi)	Whole skeletal Muscle Mass	Fat free mass (FFM)
		<p>Mean (SD): 34.66 (6.83) kg</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 34.84 (6.78) kg</p> <p>Intervention 3: Whey-Soy protein group (1:1 ratio of whey and soy blended supplement: 8.39 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 35.49 (6.49) kg</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 35.77 (6.57) kg</p> <p>Comparator 1: Control (no supplementation) Baseline: n Analyzed: 30 Mean (SD): 33.79 (6.17) kg</p> <p>Follow-up (6 months): n Analyzed: 30 Mean (SD): 33.32 (6.0) kg</p> <p>Between group comparison and p-value: Statistically different from comparator (p<0.05)</p>	<p>Mean (SD): 14.46 (3.27) kg</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 14.54 (3.27) kg</p> <p>Intervention 3: Whey-Soy protein group (1:1 ratio of whey and soy blended supplement: 8.39 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 15.07 (3.33) kg</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 15.26 (3.38) kg</p> <p>Comparator 1: Control (no supplementation) Baseline: n Analyzed: 30 Mean (SD): 14.13 (3.03) kg</p> <p>Follow-up (6 months): n Analyzed: 30 Mean (SD): 13.76 (2.98) kg</p> <p>Between group comparison and p-value: Statistically different from comparator (p<0.05)</p>	<p>n Analyzed: 31 Mean (SD): 5.62 (0.83) kg/m²</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 5.65 (0.84) kg/m²</p> <p>Intervention 3: Whey-Soy protein group (1:1 ratio of whey and soy blended supplement: 8.39 g protein per supplement) Baseline n Analyzed: 31 Mean (SD): 5.68 (0.81) kg/m²</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 5.75 (0.80) kg/m²</p> <p>Comparator 1: Control (no supplementation) Baseline: n Analyzed: 30 Mean (SD): 5.65 (0.84) kg/m²</p> <p>Follow-up (6 months): n Analyzed: 30 Mean (SD): 5.50 (0.81) kg/m²</p> <p>Between group comparison and p-value: Statistically different from comparator (p<0.001)</p>		

Study	Statistics/ Confounders adjusted for	Total body lean mass	Appendicular lean mass/ skeletal muscle mass	Appendicular skeletal muscle index (ASMi)	Whole skeletal Muscle Mass	Fat free mass (FFM)
PMID: 34609621 Author: Reinders Year: 2022 ⁶¹	<p>Statistics: Linear regression model</p> <p>Confounders adjusted for: Residual confounding checked for baseline 400 m walk time, baseline protein intake, sex, and study site</p>	-	-	-	-	<p>Intervention: Protein advice (advised to increase protein intake to ≥ 1.2 g/kg aBW/d) Baseline: n Analyzed: 96 Mean (SE): 52.0 (1.06) kg</p> <p>Follow-up (6 months): n Analyzed: 96 Mean (SE): 52.6 (1.15) kg</p> <p>Comparator: Control (no advice to increase protein consumption) Baseline: n Analyzed: 91 Mean (SE): 51.8 (0.97) kg</p> <p>Follow-up (6 months): n Analyzed: 91 Mean (SE): 52.1 (0.99) kg</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05)</p>
PMID: 29687650 Author: Smith Year: 2018 ⁶²	Statistics: Linear mixed model	Intervention: Weight loss plus whey protein supplement (hypocaloric)	-	-	-	Intervention: Weight loss plus whey protein

Study	Statistics/ Confounders adjusted for	Total body lean mass	Appendicular lean mass/ skeletal muscle mass	Appendicular skeletal muscle index (ASMi)	Whole skeletal Muscle Mass	Fat free mass (FFM)
	<p>Confounders adjusted for: NR</p>	<p>diet with increased protein intake 1.2 g/kg/d Baseline: n Analyzed: 25 Mean (SEM): 44.4 (1.0) kg</p> <p>Follow-up (6 months): n Analyzed: 25 Mean (SEM): 43.3 (1.0) kg</p> <p>Comparator: Weight loss plus recommended protein Baseline: n Analyzed: 27 Mean (SEM): 45.7 (0.9) kg</p> <p>Follow-up (6 months): n Analyzed: 27 Mean (SEM): 44.2 (1.0) kg</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05)</p>				<p>supplement (hypocaloric diet with increased protein intake 1.2 g/kg/d) Baseline: n Analyzed: 25 Mean (SEM): 46.9 (1.0) kg</p> <p>Follow-up (6 months): n Analyzed: 25 Mean (SEM): 45.8 (1.0) kg</p> <p>Comparator: Weight loss plus recommended protein (hypocaloric diet with 0.8 g/kg/d protein) Baseline: n Analyzed: 27 Mean (SEM): 48.2 (1.0) kg</p> <p>Follow-up (6 months): n Analyzed: 27 Mean (SEM): 46.7 (1.0) kg</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05)</p>

Study	Statistics/ Confounders adjusted for	Total body lean mass	Appendicular lean mass/ skeletal muscle mass	Appendicular skeletal muscle index (ASMi)	Whole skeletal Muscle Mass	Fat free mass (FFM)
PMID: 22406907 Author: Wycherley Year: 2012 ³⁸	Statistics: Intention-to- treat - maximal likelihood mixed model analysis with fixed and random effects Confounders adjusted for: NR	-	-	-	-	Intervention: High Protein (35% energy from protein) Baseline: n Analyzed: 58** Mean (SD): NR Follow-up (52 weeks): n Analyzed: 58** Mean (SD): NR Comparator: Low Protein (high carbohydrate - 17% energy from protein) Baseline: n Analyzed: 62** Mean (SD): NR Follow-up (52 weeks): n Analyzed: 62** Mean (SD): NR Between group comparison and p- value: Not statistically different from comparator P = 0.17
PMID: 26400966 Author: Zhu Year: 2015 ⁶⁴	Statistics: Linear mixed- effects model analysis Confounders adjusted for: NR	-	Intervention: High Protein (supplement drink - 30 g of protein per day) Baseline: n Analyzed: 101 Mean (SD): 16.2 (2.4) kg	Intervention: High Protein (supplement drink - 30 g of protein per day) Baseline: n Analyzed: 101 Mean (SD): 6.3 (0.7) kg/m ²	-	-

Study	Statistics/ Confounders adjusted for	Total body lean mass	Appendicular lean mass/ skeletal muscle mass	Appendicular skeletal muscle index (ASMi)	Whole skeletal Muscle Mass	Fat free mass (FFM)
			<p>Follow-up (2 years): n Analyzed: 93 Mean (SEM) (Change at 2 y): -0.03 (0.07) kg</p> <p>Comparator: Placebo supplement (high- carbohydrate drink supplement drink - 2.1 g of protein per day) Baseline: n Analyzed: 95 Mean (SD): 16.6 (2.4) kg</p> <p>Follow-up (2 years): n Analyzed: 88 Mean (SEM) (Change at 2 y): 0.03 (0.08) kg</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05)</p>	<p>Follow-up (2 years): n Analyzed: 93 Mean (SEM) (Change at 2 y): 0.02 (0.03) kg/m²</p> <p>Comparator: Placebo supplement (high- carbohydrate drink supplement drink - 2.1 g of protein per day) Baseline: n Analyzed: 95 Mean (SD): 6.5 (0.8) kg/m²</p> <p>Follow-up (2 years): n Analyzed: 88 Mean (SEM) (Change at 2 y): 0.05 (0.03) kg/m²</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05)</p>		

Abbreviations: aBW = adjusted body weight; ANCOVA = analysis of covariance; ASMi = appendicular skeletal muscle index; BMI = body mass index; d = day; FFM = fat free mass; g = gram; kg = kilogram; kg/m² = kilograms per square meter; M = meter; n = number analyzed; NR = not reported; PMID = PubMed identification number; SD = standard deviation; SE = standard error; SEM = standard error of the mean

Note: *Study overlaps KQs; ** Baseline characteristics were presented for participants who completed the 52-week intervention; but intention-to-treat evaluation was conducted for the full sample.

Table E14. Sarcopenia RCT: Muscle strength Outcome

Study	Statistics/ Confounder s adjusted for	Handgrip strength	1-RM leg press	Knee flexor strength	Leg extensor strength	Sum 1-RM strength (sum of leg press, knee extension, and knee flexion)	Sum knee extension peak torque	Sum knee flexion peak torque	Chair Stand
PMID: 2647134 4 Author: Backx Year: 2016 ⁵⁶	Statistics: ANCOVA Cofounders adjusted for: BMI, gender, age, fasting glucose	Intervention: High protein diet (contain 1.7 g of protein/kg/day) Baseline: n Analyzed: 30 Mean (SD): 40 (11) kg Follow-up: n Analyzed: 30 Mean (SD): 37 (9) kg Comparator: Normal Protein diet (contain 0.9 g protein/kg/day) Baseline: n Analyzed: 30 Mean (SD): 41 (10) kg Follow-up: n Analyzed: 30 Mean (SD): 40 (11) kg Between group comparison and p-value: Not statistically different from	Intervention: High protein diet (contain 1.7 g of protein/kg/da y) Baseline: n Analyzed: 28 Mean (SD): 152 (44) kg Follow-up: n Analyzed: 28 Mean (SD): 143 (39) kg Comparator: Normal Protein diet (contain 0.9 g protein/kg/da y) diet Baseline: n Analyzed: 25 Mean (SD): 157 (33) kg Follow-up: n Analyzed: 25 Mean (SD): 148 (30) kg	-	1-RM leg extension Intervention: High protein diet (contain 1.7 g of protein/kg/da y) Baseline: n Analyzed: 27 Mean (SD): 93 (31) kg Follow-up: n Analyzed: 27 Mean (SD): 91 (29) kg Comparator: Normal Protein diet (contain 0.9 g protein/kg/da y) Baseline: n Analyzed: 26 Mean (SD): 98 (25) kg Follow-up: n Analyzed: 26	-	-	-	-

Study	Statistics/ Confounders adjusted for	Handgrip strength	1-RM leg press	Knee flexor strength	Leg extensor strength	Sum 1-RM strength (sum of leg press, knee extension, and knee flexion)	Sum knee extension peak torque	Sum knee flexion peak torque	Chair Stand
		comparator P = 0.210)	Between group comparison and p-value: Not statistically different from comparator P = 0.689		Mean (SD): 94 (25) kg Between group comparison and p-value: Not statistically different from comparator P = 0.296				
PMID: 33975325 Author: Englert Year: 2021 ⁵⁷	Statistics: T-test Confounders adjusted for: NR	Intervention: High Protein (1.5 g/kg body weight/day) Baseline: n Analyzed: 27 Mean (SD): 28.7 (7.2) kg Follow-up (12 weeks): n Analyzed: 27 Mean (SD) (Change at 12 weeks): +0.01 (2.6) kg Comparator: Normal Protein (0.8 g/kg body weight/day) Baseline: n Analyzed: 27	-	-	-	-	-	-	-

Study	Statistics/ Confounder s adjusted for	Handgrip strength	1-RM leg press	Knee flexor strength	Leg extensor strength	Sum 1-RM strength (sum of leg press, knee extension, and knee flexion)	Sum knee extension peak torque	Sum knee flexion peak torque	Chair Stand
		<p>Mean (SD): 29.0 (4.9) kg</p> <p>Follow-up (12 weeks): n Analyzed: 27 Mean (SD) (Change at 12 weeks): -1.6 (3.3) kg</p> <p>Between group comparison and p-value: Statistically different from comparator P = 0.041</p>							
<p>PMID: 3361243 9 Author: Li Year: 2021⁶⁰</p>	<p>Statistics: ANCOVA</p> <p>Confounders adjusted for: Sex, age, height, physical activity level, total dietary energy intake</p>	<p>Intervention 1: Whey Protein (whey protein blended supplement twice daily: 7.98 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 27.06 (7.78) kg</p> <p>Follow-up: n Analyzed: 31 Mean (SD): 26.78 (7.93) kg</p> <p>Intervention 2:</p>	-	-	-	-	-	-	<p>Intervention 1: Whey Protein (whey protein blended supplement twice daily: 7.98 g protein per supplement Baseline: n Analyzed: 31 Mean (SD): 8.95 (1.54) s</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 8.22 (1.48) s</p>

Study	Statistics/ Confounder s adjusted for	Handgrip strength	1-RM leg press	Knee flexor strength	Leg extensor strength	Sum 1-RM strength (sum of leg press, knee extension, and knee flexion)	Sum knee extension peak torque	Sum knee flexion peak torque	Chair Stand
		<p>Soy protein (soy protein blended supplement twice daily: 8.80 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 26.88 (6.93) kg</p> <p>Follow-up: n Analyzed: 31 Mean (SD): 27.48 (7.03) kg</p> <p>Intervention 3: Whey-Soy protein group (1:1 ratio of whey and soy blended supplement: 8.39 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 28.42 (8.81) kg</p> <p>Follow-up: n Analyzed: 31 Mean (SD): 28.45 (8.17) kg</p>							<p>Intervention 2: Soy protein (soy protein blended supplement twice daily: 8.80 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 8.43 (1.63) s</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 7.60 (1.71) s</p> <p>Intervention 3: Whey-Soy protein group (1:1 ratio of whey and soy blended supplement: 8.39 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 8.68 (1.37) s</p> <p>Follow-up (6 months): n Analyzed: 31</p>

Study	Statistics/ Confounder s adjusted for	Handgrip strength	1-RM leg press	Knee flexor strength	Leg extensor strength	Sum 1-RM strength (sum of leg press, knee extension, and knee flexion)	Sum knee extension peak torque	Sum knee flexion peak torque	Chair Stand
		<p>Comparator: Control (no supplementatio n) Baseline: n Analyzed: 30 Mean (SD): 24.90 (7.33) kg</p> <p>Follow-up: n Analyzed: 30 Mean (SD): 25.33 (6.63) kg</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05)</p>							<p>Mean (SD): 8.25 (1.36) s</p> <p>Comparator: Control (no supplementatio n) Baseline: n Analyzed: 30 Mean (SD): 8.32 (1.32) s</p> <p>Follow-up (6 months): n Analyzed: 30 Mean (SD): 9.72 (1.89) s</p> <p>Between group comparison and p-value: Statistically different from comparator (p<0.001)</p>
PMID: 3460962 1 Author: Reinder s Year: 2022 ⁶¹	<p>Statistics: Linear regression model</p> <p>Confounders adjusted for: Residual confounding checked for baseline 400 m walk time,</p>	<p>Intervention: Protein advice (advised to increase protein intake to ≥1.2 g/kg aBW/d) Baseline: n Analyzed: 96 Mean (SE): 30.2 (1.04) kg</p>	-	-	<p>Leg extension strength</p> <p>Intervention: Protein advice (advised to increase protein intake to ≥1.2 g/kg aBW/d)</p>	-	-	-	-

Study	Statistics/ Confounder s adjusted for	Handgrip strength	1-RM leg press	Knee flexor strength	Leg extensor strength	Sum 1-RM strength (sum of leg press, knee extension, and knee flexion)	Sum knee extension peak torque	Sum knee flexion peak torque	Chair Stand
	baseline protein intake, sex, and study site	<p>Follow-up (6 months): n Analyzed: 96 Mean (SE): 29.3 (1.05) kg</p> <p>Comparator: Control (no advice to increase protein consumption) Baseline: n Analyzed: 91 Mean (SE): 29.2 (0.96) kg</p> <p>Follow-up (6 months): n Analyzed: 91 Mean (SE): 27.8 (0.93) kg</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05)</p>			<p>Baseline: n Analyzed: 96 Mean (SE): 309.4 (14.5) N</p> <p>Follow-up (6 months): n Analyzed: 96 Mean (SE): 326.1 (14.2) N</p> <p>Comparator: Control (no advice to increase protein consumption) Baseline: n Analyzed: 91 Mean (SE): 311.4 (12.9) N</p> <p>Follow-up (6 months): n Analyzed: 91 Mean (SE): 295.5 (12.4) N</p> <p>Between group</p>				

Study	Statistics/ Confounders adjusted for	Handgrip strength	1-RM leg press	Knee flexor strength	Leg extensor strength	Sum 1-RM strength (sum of leg press, knee extension, and knee flexion)	Sum knee extension peak torque	Sum knee flexion peak torque	Chair Stand
					comparison and p-value: Statistically different from comparator (p<0.05)				
PMID: 29687650 Author: Smith Year: 2018 ⁶²	Statistics: Linear mixed model Confounders adjusted for: NR	-	-	-	-	Intervention : Weight loss plus whey protein supplement (hypocaloric diet with increased protein intake 1.2 g/kg/d) Baseline: n Analyzed: 25 Mean (SEM): 170 (6) kg Follow-up (6 months): n Analyzed: 25 Mean (SEM): 173 (6) kg Comparator : Weight loss plus recommended protein (hypocaloric diet with 0.8	Intervention : Weight loss plus whey protein supplement (hypocaloric diet with increased protein intake 1.2 g/kg/d) Baseline: n Analyzed: 25 Mean (SEM): 326 (14) Nm Follow-up (6 months): n Analyzed: 25 Mean (SEM): 309 (13) Nm Comparator : Weight loss plus recommended protein (hypocaloric diet with 0.8	Intervention : Weight loss plus whey protein supplement (hypocaloric diet with increased protein intake 1.2 g/kg/d) Baseline: n Analyzed: 25 Mean (SEM): 188 (7) Nm Follow-up (6 months): n Analyzed: 25 Mean (SEM): 183 (6) Nm Comparator : Weight loss plus recommended protein (hypocaloric diet with 0.8	-

Study	Statistics/ Confounders adjusted for	Handgrip strength	1-RM leg press	Knee flexor strength	Leg extensor strength	Sum 1-RM strength (sum of leg press, knee extension, and knee flexion)	Sum knee extension peak torque	Sum knee flexion peak torque	Chair Stand
						g/kg/d protein) Baseline: n Analyzed: 27 Mean (SEM): 163 (6) kg Follow-up (6 months): n Analyzed: 27 Mean (SEM): 164 (6) kg Between group comparison and p-value: Not statistically different from comparator (p>0.05)	g/kg/d protein) Baseline: n Analyzed: 27 Mean (SEM): 305 (13) Nm Follow-up (6 months): n Analyzed: 27 Mean (SEM): 303 (13) Nm Between group comparison and p-value: Not statistically different from comparator (p>0.05)	g/kg/d protein) Baseline: n Analyzed: 27 Mean (SEM): 178 (7) Nm Follow-up (6 months): n Analyzed: 27 Mean (SE): 177 (7) Nm Between group comparison and p-value: Not statistically different from comparator (p>0.05)	
PMID: 26400966 Author: Zhu Year: 2015 ⁶⁴	Statistics: Linear mixed-effects model analysis Confounders adjusted for: NR	Intervention: High Protein (supplement drink - 30 g of protein per day) Baseline: n Analyzed: 99 Mean (SD): 21.7 (5.2) kg Follow-up (2 years):	-	Intervention: High Protein (supplement drink - 30 g of protein per day) Baseline: n Analyzed: 99 Mean (SD): 9.1 (3.6) kg	Knee extensor strength – strain gauge Intervention: High Protein (supplement drink - 30 g of protein per day) Baseline:	-	-	-	-

Study	Statistics/ Confounders adjusted for	Handgrip strength	1-RM leg press	Knee flexor strength	Leg extensor strength	Sum 1-RM strength (sum of leg press, knee extension, and knee flexion)	Sum knee extension peak torque	Sum knee flexion peak torque	Chair Stand
		<p>n Analyzed: 93 Mean (SEM) (Change at 2 y): -1.09 (0.41) kg</p> <p>Comparator: Placebo supplement (high- carbohydrate drink supplement drink - 2.1 g of protein per day) Baseline: n Analyzed: 94 Mean (SD): 21.7 (5.5) kg</p> <p>Follow-up (2 years): n Analyzed: 88 Mean (SEM) (Change at 2 y): -1.53 (0.42) kg</p> <p>Between group comparison and p-value: Not statistically different from comparator (p>0.05)</p>		<p>Follow-up (2 years): n Analyzed: 93 Mean (SEM) (Change at 2 y): 3.18 (0.38) kg</p> <p>Comparator: Placebo supplement (high- carbohydrat e drink supplement drink - 2.1 g of protein per day) Baseline: n Analyzed: 94 Mean (SD): 9.7 (3.7) kg</p> <p>Follow-up (2 years): n Analyzed: 88 Mean (SEM) (Change at 2 y): 2.36 (0.49) kg</p> <p>Between group</p>	<p>n Analyzed: 99 Mean (SD): 15.4 (5.3) kg</p> <p>Follow-up (2 years): n Analyzed: 93 Mean (SEM) (Change at 2 y): 3.36 (0.68) kg</p> <p>Comparator: Placebo supplement (high- carbohydrate per day) supplement drink - 2.1 g of protein per day) Baseline: n Analyzed: 94 Mean (SD): 16.1 (7.2) kg</p> <p>Follow-up (2 years): n Analyzed: 88 Mean (SEM) (Change at 2 y): 3.17 (0.80) kg</p>				

Study	Statistics/ Confounders adjusted for	Handgrip strength	1-RM leg press	Knee flexor strength	Leg extensor strength	Sum 1-RM strength (sum of leg press, knee extension, and knee flexion)	Sum knee extension peak torque	Sum knee flexion peak torque	Chair Stand
				comparison and p-value: Not statistically different from comparator (p>0.05)	Between group comparison and p-value: Not statistically different from comparator (p>0.05)				

Abbreviations: aBW = adjusted body weight; ANCOVA = analysis of covariance; BMI = body mass index; d = day; g = gram; kg = kilogram; n = number analyzed; N = newtons; Nm = newton meter; NR = not reported; PMID = PubMed identification number; RM = repetition maximum; SD = standard deviation; SE = standard error; SEM = standard error of the mean; y = years

Table E15. Sarcopenia RCT: Physical Performance Outcome

Study	Statistics/ Confounders adjusted for	Timed Up-and-Go (TUG)	4m walk gait speed	400m walk speed	SPPB
PMID: 26471344 Author: Backx Year: 2016 ⁵⁶	Statistics: ANCOVA Cofounders adjusted for: BMI, gender, age, fasting glucose	-	-	Intervention: High protein diet (contain 1.7 g of protein/kg/day) Baseline: n Analyzed: 30 Mean (SD): 1.46 (0.19) m/s Follow-up: n Analyzed: 30 Mean (SD): 1.5 (0.2) m/s Comparator: Normal Protein diet (contain 0.9 g protein/kg/day) Baseline: n Analyzed: 29 Mean (SD): 1.45 (0.19) m/s	Intervention: High protein diet (contain 1.7 g of protein/kg/day) Baseline: n Analyzed: 31 Mean (SD): 11.6 (0.7) Follow-up: n Analyzed: 30 Mean (SD): 11.7 (0.5) Comparator: Normal Protein diet (contain 0.9 g protein/kg/day) Baseline: n Analyzed: 30 Mean (SD): 11.4 (0.9)

Study	Statistics/ Confounders adjusted for	Timed Up-and-Go (TUG)	4m walk gait speed	400m walk speed	SPPB
				<p>Follow-up: n Analyzed: 29 Mean (SD): 1.47 (0.22) m/s</p> <p>Between group comparison and p-value: Not statistically different from comparator P = 0.219</p>	<p>Follow-up: n Analyzed: 30 Mean (SD): 11.6 (0.6)</p> <p>Between group comparison and p-value: Not statistically different from comparator P= 0.483</p>
<p>PMID: 33975325 Author: Englert Year: 2021⁵⁷</p>	<p>Statistics: T-test</p> <p>Confounders adjusted for: NR</p>	-	-	<p>Intervention: High Protein (1.5 g/kg body weight/day) Baseline: n Analyzed: 27 Mean (SD): 4:10 (0:33) min:sec</p> <p>Follow-up (12 weeks): N Analyzed: 27 Mean (SD) (Change at 12 weeks): -0:00 (0:07) min:sec</p> <p>Comparator: Normal Protein (0.8 g/kg body weight/day) Baseline: n Analyzed: 27 Mean (SD): 4:11 (0:31) min:sec</p> <p>Follow-up (12 weeks): N Analyzed: 27 Mean (SD) (Change at 12 weeks): -0:05 (0:12) min:sec</p> <p>Between group comparison and p-value: Not statistically different from comparator P= 0.281</p>	<p>Intervention: High Protein (1.5 g/kg body weight/day) Baseline: n Analyzed: 27 Mean (SD): 9.4 (1.1)</p> <p>Follow-up (12 weeks): n Analyzed: 27 Mean (SD) (Change at 12 weeks): +0.4 (0.09)</p> <p>Comparator: Normal Protein (0.8 g/kg body weight/day) Baseline: n Analyzed: 27 Mean (SD): 9.9 (1.0)</p> <p>Follow-up (12 weeks): n Analyzed: 27 Mean (SD) (Change at 12 weeks): +0.6 (0.8)</p> <p>Between group comparison and p-value: Not statistically different from comparator P= 0.463</p>
<p>PMID: 33612439</p>	<p>Statistics: ANCOVA</p>	-	Intervention 1:	-	Intervention 1: Whey Protein (whey protein)

Study	Statistics/ Confounders adjusted for	Timed Up-and-Go (TUG)	4m walk gait speed	400m walk speed	SPPB
Author: Li Year: 2021 ⁶⁰	Confounders adjusted for: Sex, age, height, physical activity level, total dietary energy intake		<p>Whey Protein (whey protein blended supplement twice daily: 7.98 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD):1.12 (0.2) m/s</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 1.14 (0.12) m/s</p> <p>Intervention 2: Soy protein (soy protein blended supplement twice daily: 8.80 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 1.17 (0.16) m/s</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 1.15 (0.14) m/s</p> <p>Intervention 3: Whey-Soy protein group (1:1 ratio of whey and soy blended supplement: 8.39 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 1.15 (0.20) m/s</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 1.13 (0.17) m/s</p> <p>Comparator 1:</p>		<p>blended supplement twice daily: 7.98 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 11.23 (0.8)</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 11.65 (0.61)</p> <p>Intervention 2: Soy protein (soy protein blended supplement twice daily: 8.80 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 11.58 (0.56)</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 11.52 (0.63)</p> <p>Intervention 3: Whey-Soy protein group (1:1 ratio of whey and soy blended supplement: 8.39 g protein per supplement) Baseline: n Analyzed: 31 Mean (SD): 11.39 (0.88)</p> <p>Follow-up (6 months): n Analyzed: 31 Mean (SD): 11.71 (0.78)</p> <p>Comparator 1: Control (no supplementation) Baseline: n Analyzed: 30 Mean (SD): 11.51 (0.62)</p>

Study	Statistics/ Confounders adjusted for	Timed Up-and-Go (TUG)	4m walk gait speed	400m walk speed	SPPB
			Control (no supplementation) Baseline: n Analyzed: 30 Mean (SD): 1.12 (0.1) m/s Follow-up (6 months): n Analyzed: 30 Mean (SD): 0.96 (0.16) m/s Between group comparison and p-value: Statistically different from comparator (p<0.05)		Follow-up (6 months): n Analyzed: 30 Mean (SD): 10.61 (1.28) Between group comparison and p-value: Statistically different from comparator (p<0.01)
PMID: 34609621 Author: Reinders Year: 2022⁶¹	Statistics: Linear regression model Confounders adjusted for: Residual confounding checked for baseline 400 m walk time, baseline protein intake, sex, and study site	-	-	Intervention: Protein advice (advised to increase protein intake to ≥ 1.2 g/kg aBW/d) Baseline: n Analyzed: 96 Mean (SE): 311.3 (7.2) s Follow-up (6 months): n Analyzed: 96 Mean (SE): 306.0 (6.85) s Comparator: Control (no advice to increase protein consumption) Baseline: n Analyzed: 91 Mean (SE): 311.1 (9.3) s Follow-up (6 months): n Analyzed: 91 Mean (SE): 318.2 (11.0) s Between group comparison and p-value: Statistically	Intervention: Protein advice (advised to increase protein intake to ≥ 1.2 g/kg aBW/d) Baseline: n Analyzed: 96 Mean (SE): 9.8 (0.14) Follow-up (6 months): n Analyzed: 96 Mean (SE): 10.0 (0.14) Comparator: Control (no advice to increase protein consumption) Baseline: n Analyzed: 91 Mean (SE): 9.7 (0.17) Follow-up (6 months): n Analyzed: 91 Mean (SE): 10.0 (0.17) Between group comparison and p-value: Not statistically different from comparator (p>0.05)

Study	Statistics/ Confounders adjusted for	Timed Up-and-Go (TUG)	4m walk gait speed	400m walk speed	SPPB
				different from comparator (p<0.05)	
PMID: 26400966 Author: Zhu Year: 2015 ⁶⁴	Statistics: Linear mixed-effects model analysis Confounders adjusted for: NR	<p>Intervention: High Protein (supplement drink - 30 g of protein per day) Baseline: n Analyzed: 99 Mean (SD): 7.9 (1.3) s</p> <p>Follow-up (2 years): n Analyzed: 93 Mean (SEM) (Change at 2 y): 0.46 (0.12) s</p> <p>Comparator: Placebo supplement (high-carbohydrate drink supplement drink - 2.1 g of protein per day) Baseline: n Analyzed: 94 Mean (SD): 8.0 (1.5) s</p> <p>Follow-up (2 years): n Analyzed: 88 Mean (SEM) (Change at 2 y): -0.55 (0.12) s</p> <p>Between group comparison and p-value: Not statistically different from comparator (p >0.05)</p>	-	-	-

Abbreviations: aBW = adjusted body weight; ACOVA = analysis of covariance; BMI = body mass index; d = day; g = grams; kg = kilograms; m = meter; n = number analyzed; NR = not reported; PMID = PubMed identification number; s = second; SD = standard deviation; SE = standard error; SEM = standard error of the mean; SPBB = Short Physical Performance Battery

Appendix F. Chronic Condition Clinical Endpoints in Studies Not in the Analytic Set

Table F1. Summary of findings for clinical endpoint outcomes for risk of bone disease: adults

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment methods	Mean protein intake	Outcome Findings	Direction of Effect	Risk of bias
Beasley, 2014 ¹¹	Fragility fracture (osteoporotic and low-trauma fracture) Hip fracture Spine fracture Forearm fracture Tertile 1: Protein intake <13.3% of energy Tertile 2: Protein intake 14.2-14.8% of energy Tertile 3: Protein intake ≥15.6% of energy	Country: U.S. Study Design: Prospective cohort study n analyzed: n=144,580 Mean age (SD): Tertile 1: 66 (7.2) y Tertile 2: 63.7 (6.9) y Tertile 3: 59.6 (6.4) y Sex: 100% female 6 years	FFQ	*Tertile 1: <13.3% of energy *Tertile 2: 14.2-14.8% of energy *Tertile 3: ≥15.6% of energy	Fragility fracture (osteoporotic and low-trauma fracture) Highest protein intake tertile versus lowest tertile: HR: 0.99 (0.97, 1.02) per 20% increase in calibrated protein intake Hip fracture: Highest protein intake tertile versus lowest tertile: HR: 0.91 (0.84, 1.00) per 20% increase in calibrated protein intake Spine fracture: Highest protein intake tertile versus lowest tertile: HR: 1.05 (0.98, 1.13) per 20% increase in calibrated protein intake Forearm fracture: Highest protein intake tertile versus lowest tertile: HR: 0.93 (0.88, 0.98) per 20% increase in calibrated protein intake	No difference	High
Cauley, 2016 ¹²	Hip fracture Arm 1: No hip fracture Arm 2: Hip fracture	Country: U.S. Study Design: Prospective cohort study n analyzed: Arm 1: n=5,698 Arm 2: n=178	FFQ	*Arm 1: 16.13 (2.91) % of energy *Arm 2: 15.3 (2.55) % of energy	For each SD increase in total energy from protein: HR: 0.76 (0.64, 0.89)	Found benefit	Very High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment methods	Mean protein intake	Outcome Findings	Direction of Effect	Risk of bias
		Mean age (SD): Arm 1: 73.48 (5.81) y Arm 2: 77.81 (6.08) y Sex: 0% female 8.6 years					
Dargent-Molina, 2008 ¹⁴	Fragility fracture (osteoporotic and low-trauma fracture) Arm 1: No fractures Arm 2: Fractures	Country: France Study Design: Prospective cohort study n analyzed: Arm 1: n=33,809 Arm 2: n=2,408 Mean (SD) age: Arm 1: 56.1 (5.5) y Arm 2: 57.1 (5.6) y Sex: 100% female 15 years	Dietary questionnaire	*Arm 1: 45.7 (7.3) g/1000 kcal/d *Arm 2: 46.0 (7.6) g/1000 kcal/d	Highest protein intake quartile versus lowest quartile: RR: 1.06 (0.94,1.19)	No difference	High
Key, 2007 ¹⁸	Fragility fracture (osteoporotic and low-trauma fracture) Arm 1: Women Arm 2: Men	Country: Australia Study design: Prospective cohort study n analyzed: Arm 1: n=26,749	FFQ	*Arm 1: 73.1 (21.6) g/d *Arm 2: 77.8 (22.6) g/d	Highest protein intake quintile versus lowest quintile: Arm 1: Women RR: 0.97 (0.74,1.27) Arm 2: Men: RR: 1.29 (0.72,2.31)	No difference	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment methods	Mean protein intake	Outcome Findings	Direction of Effect	Risk of bias
		Arm 2: n=7,947 Mean (SD) age: Arm 1: 45.8 (13.1) y Arm 2: 49.5 (13.5) y Sex: Arm 1: 100% female Arm 2: 0% female 6 years					
Langsetmo, 2015 ¹⁹	Fragility fracture (osteoporotic and low-trauma fracture) Arm 1: Men Arm 2: Women	Country: Canada Study Design: Prospective cohort study Prospective cohort study n analyzed: Arm 1: n=1,919 Arm 2: n=4,591 Mean (SD) age: NR Sex: Arm 1: 0% female Arm 2: 100% female 5 years	FFQ	*Arm 1: 13.6 (12.0-15.1) % of energy *Arm 2: 14.3 (12.8-15.9) % of energy	Fragility fracture: Highest protein intake quartile vs lowest quartile: Arm 1: HR: 0.66 (0.35,1.24) Arm 2: HR: 0.85 (0.64,1.09)	No difference	High
Langsetmo, 2017 ²⁰	Fragility fracture (osteoporotic fracture)	Country: U.S.	FFQ	*Quartile 1: 6.0-14.1% of energy	Fragility fracture (osteoporosis fracture) Highest protein intake quartile vs lowest quartile:	Found benefit	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment methods	Mean protein intake	Outcome Findings	Direction of Effect	Risk of bias
	Fragility fracture (low-trauma) Hip fracture Spine fracture Quartile 1: Protein intake 6.0-14.1% of energy Quartile 2: Protein intake 14.2-15.8% of energy Quartile 3: Protein intake 15.9-17.7% of energy Quartile 4: Protein intake 17.8-29.3% of energy	Study Design: Prospective cohort study n analyzed: Quartile 1: n=1,469 Quartile 2: n=1,469 Quartile 3: n=1,469 Quartile 4: n=1,468 Mean (SD) age: Quartile 1: 73.6 (5.9) y Quartile 2: 74.0 (5.8) y Quartile 3: 73.6 (5.9) y Quartile 4: 73.4 (5.9) y Sex: 0% female 15 years		*Quartile 2: 14.2-15.8% of energy *Quartile 3: 15.9-17.7% of energy *Quartile 4: 17.8-29.3% of energy	HR: 0.92 (0.84, 1.00) Fragility fracture (low trauma) Highest protein intake quartile vs lowest quartile: HR: 0.92 (0.85–0.99) Hip fracture Highest protein intake quartile vs lowest quartile: HR: 0.84 (0.73, 0.95) Spine fracture Highest protein intake quartile vs lowest quartile: HR: 1.06 (0.92–1.22)		
Misra, 2011 ²⁴	Hip fracture Arm 1: No hip fracture Arm 2: Hip fracture	Country: U.S. Study Design: Prospective cohort study n analyzed: Arm 1: n=846 Arm 2: n=100 Mean (SD) age: Arm 1: 75 (5.0) y	FFQ	*Arm 1: 64.2 g/d *Arm 2: 63.6 g/d	Upper three protein intake quartiles vs lowest quartile: HR: 0.63 (0.41, 0.97)	Found benefit	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment methods	Mean protein intake	Outcome Findings	Direction of Effect	Risk of bias
		Arm 2: 76 (5.2) y Sex: Arm 1: 58.6% female Arm 2: 80.0% female 16-17 years					
Nakano, 2023 ²⁵	Fragility fracture (osteoporotic fracture) Arm 1: whole cohort	Country: U.S. Study Design: Prospective cohort study n analyzed: 1,070 Mean (SD) age: 69.3 (10.9) y Sex: 100% female 5.8 years	FFQ	*73.4 (15.1) g/d	HR: 1.07 (0.90, 1.27) higher protein/energy intake ratio	No difference	High
Sahni, 2010 ²⁸	Hip fracture Arm 1: Men Arm 2: Women	Country: U.S. Study Design: Prospective cohort study n analyzed: Arm 1: n=1,725 Arm 2: n=1,931 Mean age (SD): Arm 1: 55.3 (9.9) y Arm 2: 54.9 (9.8) y	FFQ	*Arm 1: 79.0 (27) g/d *Arm 2: 75.7 (27) g/d	Total calcium intake < 800 mg/d Highest protein intake tertile versus lowest tertile: HR: 2.20 (0.88, 5.54) Total calcium intake ≥ 800 mg/d Highest protein intake tertile versus lowest tertile: HR: 0.54 (0.12, 1.30)	No difference	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment methods	Mean protein intake	Outcome Findings	Direction of Effect	Risk of bias
		Sex: Arm 1: 0% female Arm 2: 100% female 7-10 years					
Sellmeyer, 2001 ³⁰	Hip fracture Tertile 1: Low ratio of animal to vegetable protein Tertile 2: Medium ratio of animal to vegetable protein Tertile 3: High ratio of animal to vegetable protein	Country: U.S. Study design: Prospective cohort study n analyzed: n=1,035 Mean (SD) age: Tertile 1: 74.3 (5.4) y Tertile 2: 73.2 (4.9) y Tertile 3: 72.5 (4.5) y Sex: 100% female 7 years	FFQ	*Tertile 1: 42.0 (15.9) g *Tertile 2: 49.2 (16.9) g *Tertile 3: 58.3 (20.0) g	Highest versus lowest tertile (high ratio of animal to vegetable protein intake vs low ratio): RR: 3.7, P=0.04	Found harm	High
Weaver, 2021 ³¹	Fragility fracture (low-trauma) Tertile 1: Protein intake <13% of energy Tertile 2: Protein intake 13-15% of energy Tertile 3: Protein intake >15% of energy	Country: U.S. Study Design: Prospective cohort study n analyzed: Tertile 1: n=718 Tertile 2: n=703 Tertile 3: n=739	FFQ	*Tertile 1: 12 (1) % of energy *Tertile 2: 14 (1) % of energy *Tertile 3: 18 (2) % of energy	Highest protein intake tertile vs lowest tertile: HR: 0.71 (0.45, 1.11)	No difference	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment methods	Mean protein intake	Outcome Findings	Direction of Effect	Risk of bias
		Mean (SD) age: Tertile 1: 73.5 (2.9) y Tertile 2: 73.4 (2.8) y Tertile 3: 73.7 (2.9) y 5 years					

Abbreviations: d = day; FFQ = food frequency questionnaire; g = gram; HR = hazard ratio; IRR = incidence rate ratio; mg = miligram; n = number; NR = not reported; RR = relative risk; U.S. = United States; y = years

*: Reported baseline Protein intake. Follow up protein intake was not reported.

Note: Outcome findings were pulled from the adjusted models, and when reported, included the highest protein intake quartile/tertile versus the reference group.

Table F2. Summary of findings for clinical endpoint outcomes for risk of kidney disease

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment method	Mean protein intake*	Outcomes Findings	Direction of Effect	Risk of bias
Alviridzadeh, 2020 ³⁹	Incident CKD Tertile 1: Lower protein intake Tertile 2: Moderate protein intake Tertile 3: Higher protein intake	Country: Iran Study design: Prospective cohort study n=1,630 Mean (SD)age: Tertile 1: Lower protein intake: 43.3 (11.3) y Tertile 2: Moderate protein intake: 42.8(10.9) y	FFQ	Tertile 1: Lower protein intake: 50.36 (9.83) g/day Tertile 2: Moderate protein intake: 74.23 (6.43) g/day Tertile 3: Higher protein intake: 114.44 (29.42) g/day	Highest protein intake tertile versus lowest tertile: OR: 0.59 (95%CI: 0.32 to 1.08)	No difference	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment method	Mean protein intake*	Outcomes Findings	Direction of Effect	Risk of bias
		<p>Tertile 3: Higher protein intake: 42.4 (11.4) y</p> <p>Sex: Tertile 1: Lower protein intake: 55.7% female Tertile 2: Moderate protein intake: 52.8% female Tertile 3: Higher protein intake: 43% female</p> <p>6.1 years</p>					
Farhadnejad, 2019 ⁴¹	<p>Incident CKD</p> <p>Tertile 1: Lower Low-Carbohydrate High-Protein Diet Score</p> <p>Tertile 2: Moderate Low-Carbohydrate High-Protein Diet Score</p> <p>Tertile 3: Higher Low-Carbohydrate High-Protein Diet Score</p>	<p>Country: Iran</p> <p>Study design: Prospective cohort study n=1,797</p> <p>Mean (SD) age: Tertile 1: Lower Low-Carbohydrate High-Protein Diet Score: 39.0 (12.5) y</p> <p>Tertile 2: Moderate Low-Carbohydrate High-Protein Diet Score: 37.1 (12.1) y</p> <p>Tertile 3: Higher Low-</p>	FFQ	<p>Tertile 1: Lower Low-Carbohydrate High-Protein Diet Score: 12.9 (1.7) %energy</p> <p>Tertile 2: Moderate Low-Carbohydrate High-Protein Diet Score: 13.0 (2.2) %energy</p> <p>Tertile 3: Higher Low-Carbohydrate High-Protein Diet Score: 15.8 (2.1) %energy</p>	Highest protein intake tertile versus lowest tertile: OR: 1.48 (95% CI: 1.03 to 2.15)	Found harm	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment method	Mean protein intake*	Outcomes Findings	Direction of Effect	Risk of bias
		Carbohydrate High-Protein Diet Score: 36.6 (12.3) y Sex: Tertile 1: Lower Low-Carbohydrate High-Protein Diet Score: 41.4% female; Tertile 2: Moderate Low-Carbohydrate High-Protein Diet Score: 56% female; Tertile 3: Higher Low-Carbohydrate High-Protein Diet Score: 63.4% female 6.1 years					
Haring, 2017 ⁴³	Incident CKD Quintile 1: Protein intake 41.1 (7.3) g/d Quintile 2: Protein intake 57.2 (3.6) g/d Quintile 3: Protein intake 69.0 (3.3) g/d	Country: U.S. Study design: Prospective cohort study n=11,952 Mean (SD) age: Quintile 1: Protein intake: 53.8 (5.8) y Quintile 2: Protein intake: 53.8 (5.7) y	FFQ	Quintile 1: Protein intake: 41.1 (7.3) g/d Quintile 2: Protein intake: 57.2 (3.6) g/d Quintile 3: Protein intake: 69.0 (3.3) g/d Quintile 4: Protein intake: 82.3 (4.5) g/d	Highest protein intake quintile versus lowest quintile: HR: 0.89 (95%CI: 0.76 to 1.05)	No difference	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment method	Mean protein intake*	Outcomes Findings	Direction of Effect	Risk of bias
	<p>Quintile 4: Protein intake 82.3 (4.5) g/d</p> <p>Quintile 5: Protein intake 109.5 (18.3) g/d</p>	<p>Quintile 3: Protein intake 69.0 (3.3) g/d: 53.8 (5.7) y</p> <p>Quintile 4: Protein intake 82.3 (4.5) g/d: 53.8 (5.7) y</p> <p>Quintile 5: Protein intake 109.5 (18.3) g/d: 53.7 (5.6) y</p> <p>Sex: Quintile 1: Protein intake 41.1 (7.3) g/d: 64.2% female</p> <p>Quintile 2: Protein intake 57.2 (3.6) g/d: 56.9% female</p> <p>Quintile 3: Protein intake 69.0 (3.3) g/d: 57.8% female</p> <p>Quintile 4: Protein intake 82.3 (4.5) g/d: 55.4% female</p> <p>Quintile 5: Protein intake 109.5 (18.3) g/d: 47.0% female</p> <p>25 years</p>		<p>Quintile 5: Protein intake: 109.5 (18.3) g/d</p>			

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment method	Mean protein intake*	Outcomes Findings	Direction of Effect	Risk of bias
Kubo, 2023 ⁴⁸	Incident CKD Quartile 1: Protein intake 12% of energy Quartile 2: Protein intake 14.2% of energy Quartile 3: Protein intake 15.9% of energy Quartile 4: Protein intake 18.9% of energy	Country: Japan Study design: Prospective cohort study n=3,277 Mean (SD) age: Quartile 1: Protein intake 12% of energy: 58.8 (7.4) y Quartile 2: Protein intake 14.2% of energy: 59.0 (8.5) y Quartile 3: Protein intake 15.9% of energy: 58.6 (8.5) y Quartile 4: Protein intake 18.9% of energy: 58.9 (8.5) y Sex: Quartile 1: Protein intake 12% of energy: 66.4% female Quartile 2: Protein intake 14.2% of energy: 63.9% female	brief-type self-administered diet history questionnaire	Quartile 1: Protein intake: 12 (1.2) %energy Quartile 2: Protein intake:14.2 (0.5) % energy Quartile 3: Protein intake 15.9 (0.6) %energy Quartile 4: Protein intake: 18.9 (2.0) %energy	Highest protein intake quartile versus lowest quartile: HR: 0.72 (95%CI: 0.52 to 0.99)	Found benefit	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment method	Mean protein intake*	Outcomes Findings	Direction of Effect	Risk of bias
		Quartile 3: Protein intake 15.9% of energy Quartile 3: Protein intake 15.9% of energy: 65% female Quartile 4: Protein intake 18.9% of energy: 64.4% female 12 years					
Kwon, 2022 ⁴⁹	Incident CKD Tertile 1: Protein intake <0.8 g/kg/d Tertile 2: Protein intake 0.8–1.3 g/kg/d Tertile 3: Protein intake >1.3 g/kg/d	Country: Korea Study design: Prospective cohort study n=7339 Mean (SD) age: Tertile 1: Protein intake <0.8 g/kg/d: 53.1 (8.8) y Tertile 2: Protein intake 0.8–1.3 g/kg/d: 51.4 (8.5) y Tertile 3: Protein intake >1.3 g/kg/d: 51.1 (8.6) y Sex:	FFQ	Tertile 1: Protein intake <0.8 g/kg/d: 0.6 (0.1) g/kg/day Tertile 2: Protein intake 0.8–1.3 g/kg/d: 1.0 (0.1) g/kg/day Tertile 3: Protein intake >1.3 g/kg/d: 1.7 (0.4) g/kg/day	Highest protein intake tertile versus lowest tertile: HR: 0.63 (95%CI: 0.44 to 0.89)	Found benefit	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment method	Mean protein intake*	Outcomes Findings	Direction of Effect	Risk of bias
		Tertile 1: Protein intake <0.8 g/kg/d: 52.9% female Tertile 2: Protein intake 0.8–1.3 g/kg/d: 50.6% female Tertile 3: Protein intake >1.3 g/kg/d: 57.1% female 16 years					
Lew, 2017 ⁵⁰	Incident ESRD	Country: Singapore Study design: Prospective cohort study n=60,198 Mean (SD) age: Quartile 1: 12.5 g/d median red meat intake: 56.5 (7.8) y Quartile 2: 24.2 g/d median red meat intake: 56.9 (8.1) y Quartile 3: 33.4 g/d median red meat intake: 56.5 (8.1) y Quartile 4: 48.8 g/d median red meat intake: 55.7 (7.9) y Sex:	FFQ	Quartile 1: 12.5 g/d median red meat intake: 53.1 (10.3) g/d Quartile 2: 24.2 g/d median red meat intake: 57.6 (7.9) g/d Quartile 3: 33.4 g/d median red meat intake: 60.5 (7.6) g/d Quartile 4: 48.8 g/d median red meat intake: 65.3 (9.0) g/d	Highest median red meat intake quartile versus lowest quartile: HR: 1.19 (95%CI: 0.98 to 1.44)	No difference	High

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment method	Mean protein intake*	Outcomes Findings	Direction of Effect	Risk of bias
		Quartile 1: 12.5 g/d median red meat intake: 50% female Quartile 2: 24.2 g/d median red meat intake: 46% female Quartile 3: 33.4 g/d median red meat intake: 56% female Quartile 4: 48.8 g/d median red meat intake: 55% female 5 years					
Malhotra, 2016 ⁵¹	Incident ESRD Incident end-stage renal disease cases versus Control Group	Country: U.S. Study design: Case-control study n=4,255 Mean (SD) age: Incident end-stage renal disease cases: 54.5 (9.1) y Control Group: 54.6 (8.8) y Sex: Incident end-stage renal disease cases: 54.4% female Control Group: 55.2% female	FFQ and 24 h dietary recalls	Incident end-stage renal disease cases: 15.7 (3.3) %energy Control Group: 15.1 (3.1) %energy	Incident end-stage renal disease cases versus Control Group: OR=1.76 (95% CI: 1.17 to 2.65)	Found harm	Very high

Author (year)	Outcome Arms	Population n analyzed Age Sex Study Duration	Protein assessment method	Mean protein intake*	Outcomes Findings	Direction of Effect	Risk of bias
		7 years					
Teymoori, 2022 ⁵⁵	Incident CKD Tertile 1: Protein score (8.2 ± 2.8) Tertile 2: Protein score (9.6 ± 2.8) Tertile 3: Protein score (12.0 ± 3.1)	Country: Iran Study design: Prospective cohort study n=6,044 Mean (SD) age: Tertile 1: Protein score (8.2 ± 2.8): 36.1(12.1) y Tertile 2: Protein score (9.6 ± 2.8): 37.8 (12.8) y Tertile 3: Protein score (12.0 ± 3.1): 40.4 (13.3) y Sex: Tertile 1: Protein score (8.2 ± 2.8): 57.7% female; Tertile 2: Protein score (9.6 ± 2.8): 54.9% female; Tertile 3: Protein score (12.0 ± 3.1): 48.8% female 19 years	FFQ	Tertile 1: Protein score (8.2 ± 2.8): 13.1 (1.8) %energy Tertile 2: Protein score (9.6 ± 2.8): 14.8 (3.2) %energy Tertile 3: Protein score (12.0 ± 3.1): 16.1 (9.8) %energy	Highest protein score tertile versus lowest tertile: HR=0.91 (95% CI: 0.78 to 1.05)	No difference	High

Abbreviations: CI = confidence interval; CKD = chronic kidney disease; d = day; ESRD = end stage renal disease; FFQ = food frequency questionnaire; g = gram; h = hour; HR = hazard ratio; kg = kilo grams; OR = odds ratio; U.S. = United States; y = years

*: Reported baseline Protein intake. Follow up protein intake was not reported.

Note: Outcome findings were pulled from the adjusted models, and when reported, included the highest protein intake quintile/quartile/tertile versus the reference group.

Appendix G. Risk of Bias Assessments of All Eligible Studies

Table G1. Risk of Bias Assessments of Randomized Controlled Trials (Parallel Design) with RoB-2

Author, Year PMID	Bias from randomization process	Bias from deviation from intended interventions (assignment)	Bias from missing outcome data	Bias in measurement of outcome	Bias in selection of reported result	Overall risk of bias (Low, Moderate, High)
Aoyagi, 2010 ¹ PMID: NR	Low	High	High	Low	Some concerns	High
Arjmandi, 2005 ² PMID: 15727682	Low	High	High	Low	Some concerns	High
Backx, 2016 ⁵⁶ PMID: 26471344	Low	Low	Low	Low	Low	Low
Bonjour, 2012 ³ PMID: 22357739	Moderate	Low	Low	Low	Low	Moderate
Englert, 2021 ⁵⁷ PMID: 33975325	Low	Low	Low	Low	Low	Low
Flehtner-Mors, 2010 ^{*32} PMID: 20578205	Moderate	High	High	Low	Low	High
Frestedt, 2008 ^{*33} PMID: 18371214	Moderate	High	High	Low	Low	High
Haghighat, 2021 ⁵⁸ PMID: 34208986	Low	Moderate	Low	Low	Low	Moderate
Jacobs, 2010 ³⁴ PMID: 19167797	Low	Low	Low	Low	High	High
Jesudason, 2013 ^{*4} PMID: 24047916	Moderate	High	Low	Low	Low	High
Kerstetter, 2015 ^{*5} PMID: 25844619	Low	#	Low	Low	Low	#
Kruger, 2023 PMID: 37739678	Low	High	High	Low	Low	High
Li, 2010 ^{*6} PMID: 21194471	Low	High	Some concerns	Low	Some concerns	High
Li, 2021 ⁶⁰ PMID: 33612439	Low	Low	Low	Low	Low	Low
Murphy, 2021 ^{*36} PMID: 33871558	Low	High	High	Low	Low	High
Peng, 2021 ^{*37} PMID: 34098214	Low	High	High	Low	Low	High
Reinders, 2022 ⁶¹	Low	Low	Low	Low	Low	Low

Author, Year PMID	Bias from randomization process	Bias from deviation from intended interventions (assignment)	Bias from missing outcome data	Bias in measurement of outcome	Bias in selection of reported result	Overall risk of bias (Low, Moderate, High)
PMID: 34609621						
Skov, 2002 ⁷ PMID: 12055318	Low	Low	Low	Low	Low	Low
Smith, 2018 ⁶² PMID: 29687650	Low	Low	Low	Low	Low	Low
Stojkovic, 2017 ⁶³ PMID: 28492492	High	High	High	Low	Low	High
Stounbjerg, 2021 ⁸ PMID: 34581765	Low	Low	Low	Low	Low	Low
Wycherley, 2012 ^{*38} PMID: 22406907	Low	Low	Moderate	Low	Low	Moderate
Zhu, 2011 ⁹ PMID: 21590739	Low	High	High	Low	Low	High
Zhu, 2015 ⁶⁴ PMID: 26400966	Low	Low	Low	Low	Low	Low

Abbreviations: PMID = PubMed Identification Number; RoB-2 = risk of bias tool for randomized trials

Note: When at least one domain is as a high risk of bias, we determined that a study had an overall risk of bias judgement of high risk of bias (based on the RoB-2 algorithm for reaching overall risk of bias judgement), *: Studies overlap KQs, #: Kerstetter, 2015 reported on KQ1, KQ2, and KQ3 outcomes: KQ1 outcomes were assessed as both low (including BMD lumbar, hip and femoral outcomes) and high risk of bias (including all other reported outcomes); KQ2 outcomes were assessed as high risk of bias; and KQ3 outcomes were assessed as low risk of bias.

Table G2. Risk of Bias Assessments of Randomized Controlled Trials (Crossover Design) with RoB-2

Author, Year PMID	Bias from randomization process	Bias from period and carryover effects	Bias from deviation from intended interventions (assignment)	Bias from missing outcome data	Bias in measurement of outcome	Bias in selection of reported result	Overall risk of bias (Low, Moderate, High)
Juraschek, 2013 ³⁵ PMID: 23219108	Low	Low	Low	Low	Low	Low	High

Abbreviations: PMID = PubMed Identification Number; RoB-2 = risk of bias tool for randomized trials

Note: When at least one domain is as a high risk of bias, we determined that a study had an overall risk of bias judgement of high risk of bias (based on the RoB-2 algorithm for reaching overall risk of bias judgement)

Table G3. Risk of Bias Assessments of Non-randomized Controlled Trials with ROBINS-E

Author, Year PMID	Bias in selection of participants into the study (or into the analysis)	Bias due to post-exposure interventions	Bias due to missing data	Bias from measurement of the outcome	Bias in selection of the reported result	Bias due to confounding	Bias from measurement of the exposure	Overall risk of bias (Low, Moderate, High, Very high)
Alvirdizadeh, 2020 ³⁹ PMID: 33203389	Low	Low	High	Low	Low	-	-	High
Beasley, 2010 ¹⁰ PMID: 20219968	Low	Low	High	Low	Low	-	-	High
Beasley, 2013 ⁶⁵ PMID: 24219187	Low	Low	High	Low	Low	-	-	High
Beasley, 2014 ¹¹ PMID: 24552750	Low	Low	High	Low	Low	-	-	High
Cauley, 2016 ^{**12} PMID: 26988112	-	-	-	-	-	-	-	Very high
Chan, 2011 ¹³ PMID: 21437561	Low	Low	High	Low	Low	-	-	High
Chan, 2014 ⁶⁶ PMID: 24522470	Low	Low	High	Low	Low	-	-	High
Chen, 2023 ⁶⁷ PMID: 37922694	Low	Low	High	Low	Low	-	-	High
Cirillo, 2018 ⁴⁰ PMID: 29439930	Low	Low	High	Low	Low	-	-	High
Dargent-Molina, 2008 ¹⁴ PMID: 18665794	Low	Low	High	Low	Low	-	-	High
Devine, 2005 ¹⁵ PMID: 15941897	Low	Low	High	Low	Low	-	-	High

Author, Year PMID	Bias in selection of participants into the study (or into the analysis)	Bias due to post-exposure interventions	Bias due to missing data	Bias from measurement of the outcome	Bias in selection of the reported result	Bias due to confounding	Bias from measurement of the exposure	Overall risk of bias (Low, Moderate, High, Very high)
Elstgeest, 2020 ⁶⁸ PMID: 32520344	Low	Low	High	Low	Low	-	-	High
Farhadnejad, 2019 ^{**41} PMID: 30579675	Low	Low	High	Low	Low	-	-	High
Farsijani, 2016 ⁶⁹ PMID: 27465379	Low	Low	High	Low	Low	-	-	High
Granic, 2018 ⁷⁰ PMID: 29191494	Low	Low	High	Low	Low	-	-	High
Halbesma, 2009 ⁴² PMID: 19443643	Low	Low	Very high	Low	Low	-	-	Very high
Hannan, 2000 ¹⁶ PMID: 11127216	Low	Low	High	Low	Low	-	-	High
Haring, 2017 ⁴³ PMID: 28065493	Low	Low	High	Low	Low	-	-	High
Hengeveld, 2021 ⁷¹ PMID: 33515002	Low	Low	High	Low	Low	-	-	High
Herber-Gast, 2016 ⁴⁴ PMID: 27935525	Low	Low	High	Low	Low	-	-	High
Houston, 2008 ⁷² PMID: 18175749	Low	Low	High	Low	Low	-	-	High
Hruby, 2018 ⁴⁵	Low	Low	High	Low	Low	-	-	High

Author, Year PMID	Bias in selection of participants into the study (or into the analysis)	Bias due to post-exposure interventions	Bias due to missing data	Bias from measurement of the outcome	Bias in selection of the reported result	Bias due to confounding	Bias from measurement of the exposure	Overall risk of bias (Low, Moderate, High, Very high)
PMID: 30115136								
Hu, 2014 ¹⁷ PMID: 25192416	Low	Low	High	Low	Low	-	-	High
Isanejad, 2016 ^{**73} PMID: 26857389	Low	Low	High	Low	Low	-	-	Very high
Jhee, 2020 ^{**46} PMID: 31172186	Low	Low	High	Low	Low	-	-	Very high
Key, 2007 ¹⁸ PMID: 17381900	Low	Low	High	Low	Low	-	-	High
Kim, 2021 ⁷⁴ PMID: 33740517	Low	Low	High	Low	Low	-	-	High
Knight, 2003 ⁴⁷ PMID: 12639078	Low	Low	High	Low	Low	-	-	Very high
Kubo, 2023 ^{**48} PMID: 37211392	Low	Low	High	Low	Low	-	-	High
Kwon, 2022 ^{**49} PMID: 35947164	Low	Low	High	Low	Low	-	-	High
Langsetmo, 2015 ¹⁹ PMID: 26412291	Low	Low	High	Low	Low	-	-	High
Langsetmo, 2017 ²⁰ PMID: 27943394	Low	Low	High	Low	Low	-	-	High
Lew, 2017 ^{**50} PMID: 27416946	Low	Low	High	Low	Low	-	-	High

Author, Year PMID	Bias in selection of participants into the study (or into the analysis)	Bias due to post-exposure interventions	Bias due to missing data	Bias from measurement of the outcome	Bias in selection of the reported result	Bias due to confounding	Bias from measurement of the exposure	Overall risk of bias (Low, Moderate, High, Very high)
Liu, 2023 ²¹ PMID: 36986162	Low	Low	High	Low	Low	-	-	High
Malhotra, 2016 ^{**51} PMID: 27562875	Low	Low	High	Low	Low	-	-	Very high
Malhotra, 2018 ⁵² PMID: 29452887	Low	Low	Very high	Low	Low	-	-	Very high
Mangano, 2017 ^{*22} PMID: 28179224	Low	Low	High	Low	Low	-	-	High
Mendonca, 2021 ⁷⁵ PMID: 33829238	Low	Low	High	High	Low	-	-	Very high
Mendonca, 2023 ⁷⁶ PMID: 35791789	Low	Low	High	High	Low	-	-	Very high
Meng, 2009 ^{*23} PMID: 19419320	Low	Low	High	Moderate	Low	-	-	High
Misra, 2011 ²⁴ PMID: 20442986	Low	Low	High	Low	Low	-	-	High
Mulla, 2013 ⁷⁷ PMID: 22923606	Low	Low	High	Low	Low	-	-	High
Nakano, 2023 ²⁵ PMID: 36715763	Low	Low	High	Low	Low	-	-	High
Otsuka, 2020 ⁷⁸ PMID: 31608843	Low	Low	High	Low	Low	-	-	High

Author, Year PMID	Bias in selection of participants into the study (or into the analysis)	Bias due to post-exposure interventions	Bias due to missing data	Bias from measurement of the outcome	Bias in selection of the reported result	Bias due to confounding	Bias from measurement of the exposure	Overall risk of bias (Low, Moderate, High, Very high)
Promislow, 2002 ²⁶ PMID: 11914191	Low	Low	High	Low	Low	-	-	High
Rahi, 2016 ⁷⁹ PMID: 26179475	Low	Low	High	Low	Low	-	-	High
Rivera- Paredes, 2021 ²⁷ PMID: 33847345	Low	Low	Some concerns	Low	Low	Some concerns	Low	Moderate
Sahni, 2010 ²⁸ PMID: 20662074	Low	Low	High	Low	Low	-	-	High
Sahni, 2014 ²⁹ PMID: 24168918	Low	Low	High	Low	Low	-	-	High
Scott, 2010 ⁸⁰ PMID: 21054294	Low	Low	High	Low	Low	-	-	High
Sekiguchi, 2022 ⁵³ PMID: 35142012	Low	Low	High	Low	Low	-	-	High
Sellmeyer, 2001 ³⁰ PMID: 11124760	Low	Low	High	Low	Low	-	-	High
Shu, 2019 ⁵⁴ PMID: 31430246	Low	Low	Low	High	Low	-	-	High
So, 2020 ⁸¹ PMID: 32825743	Low	Low	High	Low	Low	-	-	High
Teymoori, 2022 ^{**55}	Low	Low	High	Low	Low	-	-	High

Author, Year PMID	Bias in selection of participants into the study (or into the analysis)	Bias due to post-exposure interventions	Bias due to missing data	Bias from measurement of the outcome	Bias in selection of the reported result	Bias due to confounding	Bias from measurement of the exposure	Overall risk of bias (Low, Moderate, High, Very high)
PMID: 36532536								
Weaver, 2021 ³¹ PMID: 33677533	Low	Low	High	Low	Low	-	-	High
Wham, 2021 ⁸² PMID: 34124824	Low	Low	High	Low	Low	-	-	High

Abbreviations: PMID = PubMed Identification Number; ROBINS-E = risk of bias in non-randomized studies of exposures

Note: When at least one domain is as a high risk or very high risk of bias, we determined that a study had an overall risk of bias judgement of high risk or very high risk of bias (based on the ROBINS-E algorithm for reaching overall risk of bias judgement), *: Studies overlap KQs, **: Study risk of bias assessment did not progress beyond the preliminary questions in section B of the ROBINS-E tool used to decide whether to proceed with a risk-of-bias assessment, thus detailed risk-of-bias assessment was unnecessary

Appendix H. Strength of Evidence for All Analyzed Studies

Table H1. Strength of Evidence for Bone Disease (Adults)

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
Osteocalcin										
Bonjour, 2012 ³	OC Treated group (test food - 13.8 g protein) vs usual diet)	Individuals recruited from France	1 no difference n=71 6 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
CTX and TRAP										
Bonjour, 2012 ³	CTX Treated group (test food - 13.8 g protein) vs usual diet)	Individuals recruited from France	1 no difference n=71 6 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Bonjour, 2012 ³	TRAP Treated group (test food - 13.8 g protein) vs usual diet)	Individuals recruited from France	1 found benefit n=71 6 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
BAP and P1NP										
Bonjour, 2012 ³	BAP Treated group (test food - 13.8 g protein) vs usual diet)	Individuals recruited from France	1 no difference n=71 6 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Bonjour, 2012 ³	P1NP Treated group (test food -	Individuals recruited from France	1 no difference n=71 6 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	13.8 g protein) vs usual diet)									conclusion
Lumbar spine BMD										
Kerstetter, 2015** ⁵	Lumbar spine BMD High protein (45g whey protein supplement isolate) vs low protein (carbohydrate -isocaloric maltodextrin control supplement)	Individuals recruited from U.S.	1 no difference n=171 18 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Skov, 2002 ⁷	Lumbar spine BMD High protein diet (protein - 25% of total energy) vs low protein diet (protein - 12% of total energy)	Individuals recruited from Denmark	1 no difference n=50 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Rivera-Paredes, 2021 ²⁷	Lumbar spine (L1-L4) BMD No comparison arm	Individuals recruited from Mexico	1 no difference n=317 6.4 years	1 non-RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Hip and femoral neck BMD										

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
Kerstetter, 2015**5	Total hip BMD High protein (45g whey protein supplement isolate) vs low protein (carbohydrate -isocaloric maltodextrin control supplement)	Individuals recruited from U.S.	1 no difference n=171 18 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Kerstetter, 2015**5	Femoral neck BMD High protein (45g whey protein supplement isolate) vs low protein (carbohydrate -isocaloric maltodextrin control supplement)	Individuals recruited from U.S.	1 no difference n=171 18 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Rivera-Paredes, 2021 ²⁷	Total hip BMD No comparison arm	Individuals recruited from Mexico	1 no difference n=317 6.4 years	1 non-RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Rivera-Paredes, 2021 ²⁷	Femoral neck BMD No comparison arm	Individuals recruited from Mexico	1 found benefit n=317 6.4 years	1 non-RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Total body BMD and BMC										

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
Skov, 2002 ⁷	Total body BMD High protein diet (protein - 25% of total energy) vs low protein diet (protein - 12% of total energy)	Individuals recruited from Denmark	1 no difference n=50 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Skov, 2002 ⁷	Total body BMC High protein diet (protein - 25% of total energy) vs low protein diet (protein - 12% of total energy)	Individuals recruited from Denmark	1 found benefit n=50 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Abbreviations: BAP = bone specific alkaline phosphatase; BMC = bone mineral content; BMD = bone mineral density; CTX = carboxy terminal crosslinked telopeptide of type I collagen; n = number analyzed; NA = not applicable; OC = osteocalcin; P1NP = amino-terminal propeptide of type I procollagen; RCT = randomized control trial; SoE = strength of evidence; TRAP = tartrate resistant acid phosphatase; U.S. = United States

Note: *Includes study design and RoB score, **: Study overlaps KQs

Table H2. Strength of Evidence for Bone Disease (Children and Adolescents)

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
Osteocalcin										
Stounbjerg, 2021 ⁸	Osteocalcin	Individuals recruited	1 found benefit n=184	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	High protein (9-11 g protein/100 g) vs normal protein (3.0-3.9 g protein/100 g)	from Denmark	24 weeks							on which to draw a conclusion
BMD and BMC of the lumbar spine										
Stounbjerg, 2021 ⁸	BMD lumbar spine, L1-L4 High protein (9-11 g protein/100 g) vs normal protein (3.0-3.9 g protein/100 g)	Individuals recruited from Denmark	1 found benefit n=184 24 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Stounbjerg, 2021 ⁸	BMD lumbar spine, L1-L4 zscore High protein (9-11 g protein/100 g) vs normal protein (3.0-3.9 g protein/100 g)	Individuals recruited from Denmark	1 found benefit n=184 24 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Stounbjerg, 2021 ⁸	BMC lumbar spine, L1-L4 High protein (9-11 g protein/100 g) vs normal protein (3.0-	Individuals recruited from Denmark	1 no difference n=184 24 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	3.9 g protein/100 g)									
BA lumbar spine										
Stounbjerg, 2021 ⁸	BA lumbar spine, L1-L4 High protein (9-11 g protein/100 g) vs normal protein (3.0-3.9 g protein/100 g)	Individuals recruited from Denmark	1 no difference n=184 24 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Abbreviations: BA = bone area; BMC = bone mineral content; BMD = bone mineral density; n = number analyzed; NA = Not applicable; RCT = randomized controlled trial; SoE = strength of evidence; U.S. = United States

Note: *Includes study design and RoB score

Table H3. Strength of Evidence for Kidney Disease

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
Kidney Function										
Wycherley, 2012 ^{**38}	Creatinine clearance High protein (35% energy from protein) vs low protein (high carbohydrate - 17% energy from protein)	Individuals recruited from Australia	1 no difference (n=120) ^{**} *	1 RCT Moderate risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Abbreviations: n = number analyzed; NA = Not applicable; RCT = randomized controlled trial; U.S. = United States

Note: *Includes study design and RoB score; **: Study overlaps KQs; *** Baseline characteristics were presented for participants who completed the 52-week intervention; but intention-to-treat evaluation was conducted for the full sample.

Table H4. Strength of Evidence for Sarcopenia

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
Muscle Mass										
Backx, 2016 ⁵⁶	Total body lean mass by DXA High protein diet (contain 1.7g of protein/kg/day) vs normal protein diet (contain 0.9 g protein/kg/day)	Individuals recruited from the Netherlands	1 no difference (n=NR) 12 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Kerstetter, 2015 ^{**5}	Total body lean mass by DXA High protein (45g whey protein supplement isolate) vs low protein (carbohydrate - isocaloric maltodextrin control supplement)	Individuals recruited from U.S.	1 no difference (n=207) 18 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Smith, 2018 ⁶²	Total body lean mass by DXA Weight loss plus whey protein supplement (hypocaloric diet with increased protein intake 1.2 g/kg/d) vs weight loss plus	Individuals recruited from U.S.	1 no difference (n=52) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	recommended protein (hypocaloric diet with 0.8 g/kg/d protein)									
Li, 2021 ⁶⁰	Total body lean mass by DXA Whey Protein (whey protein blended supplement), soy protein (soy protein blended supplement), whey-Soy protein group (1:1 ratio of whey and soy blended supplement) vs control (no supplementation)	Individuals recruited from China	1 found benefit (n=123) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Li, 2021 ⁶⁰	Appendicular lean mass/ skeletal muscle mass by DXA Whey Protein (whey protein blended supplement), soy protein (soy protein blended supplement), whey-Soy protein group (1:1 ratio of whey and soy blended supplement) vs	Individuals recruited from China	1 found benefit (n=123) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	control (no supplementation)									
Backx, 2016 ⁵⁶	Appendicular lean mass / skeletal muscle mass by DXA High protein diet (contain 1.7g of protein/Kg/day) vs normal protein diet (contain 0.9 g protein/Kg/day)	Individuals recruited from the Netherlands	1 no difference (n=NR) 6 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Zhu, 2015 ⁶⁴	Appendicular lean mass/ skeletal muscle mass by DXA High Protein (supplement drink - 30 g of protein per day) vs placebo supplement (high-carbohydrate drink supplement drink - 2.1 g of protein per day)	Individuals recruited from Australia	1 no difference (n=181) 2 years	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Li, 2021 ⁶⁰	Appendicular skeletal muscle mass index Whey Protein (whey protein blended supplement), soy protein (soy protein blended	Individuals recruited from China	1 found benefit (n=123) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	supplement), whey-Soy protein group (1:1 ratio of whey and soy blended supplement) vs control (no supplementation)									
Zhu, 2015 ⁶⁴	Appendicular skeletal muscle mass index High Protein (supplement drink - 30 g of protein per day) vs placebo supplement (high-carbohydrate drink supplement drink - 2.1 g of protein per day)	Individuals recruited from Australia	1 no difference (n=181) 2 years	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Haghighat, 2021 ⁵⁸	Whole skeletal muscle mass by BIA High protein (high protein snack (50g of soybeans, protein: 18.2 g)) vs low protein (~3.5 servings of fruit, protein: <2 g)	Individuals recruited from Iran	1 found benefit (n=107) 6 months	1 RCT Moderate risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Englert, 2021 ⁵⁷	FFM by BIA	Individuals recruited	1 no difference (n=54)	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	High Protein (1.5 g/kg body weight) vs normal protein (0.8 g/kg body weight)	from Germany	12 weeks							on which to draw a conclusion
Reinders, 2022 ⁶¹	FFM by BIA Protein advice (advised to increase protein intake to ≥1.2 g/kg aBW/d) vs control (no advice to increase protein consumption)	Individuals recruited from Finland and the Netherlands	1 no difference (n=187) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Smith, 2018 ⁶²	FFM by DXA Weight loss plus whey protein supplement (hypocaloric diet with increased protein intake 1.2 g/kg/d) vs weight loss plus recommended protein (hypocaloric diet with 0.8 g/kg/d protein)	Individuals recruited from U.S.	1 no difference (n=52) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Wycherley, 2012 ^{**38}	FFM by DXA High protein (35% energy from protein) vs low protein (high carbohydrate -	Individuals recruited from Australia	1 no difference (n=120) ^{**} 52 weeks	1 RCT Moderate risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	17% energy from protein)									
Physical performance										
Zhu, 2015 ⁶⁴	TUG High Protein (supplement drink - 30 g of protein per day) vs placebo supplement (high-carbohydrate drink supplement drink - 2.1 g of protein per day)	Individuals recruited from Australia	1 no difference (n=181) 2 years	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Li, 2021 ⁶⁰	4 m gait speed Whey Protein (whey protein blended supplement), soy protein (soy protein blended supplement), whey-Soy protein group (1:1 ratio of whey and soy blended supplement) vs control (no supplementation)	Individuals recruited from China	1 found benefit (n=123) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Backx, 2016 ⁵⁶	400m walk speed High protein diet (contain 1.7g of protein/Kg/day) vs normal protein	Individuals recruited from the Netherlands	1 no difference (n=59) 12 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	diet (contain 0.9 g protein/Kg/day)									
Englert, 2021 ⁵⁷	400m walk speed High Protein (1.5 g/kg body weight) vs normal protein (0.8 g/kg body weight)	Individuals recruited from Germany	1 no difference (n=54) 12 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Reinders, 2022 ⁶¹	400m walk speed Protein advice (advised to increase protein intake to ≥1.2 g/kg aBW/d) vs control (no advice to increase protein consumption)	Individuals recruited from Finland and the Netherlands	1 found benefit (n=187) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Backx, 2016 ⁵⁶	SPPB High protein diet (contain 1.7g of protein/Kg/day) vs normal protein diet (contain 0.9 g protein/Kg/day)	Individuals recruited from the Netherlands	1 no difference (n=60) 12 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Englert, 2021 ⁵⁷	SPPB High Protein (1.5 g/kg body weight) vs normal protein (0.8 g/kg body weight)	Individuals recruited from Germany	1 no difference (n=54) 12 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
Reinders, 2022 ⁶¹	SPPB Protein advice (advised to increase protein intake to ≥ 1.2 g/kg aBW/d) vs control (no advice to increase protein consumption)	Individuals recruited from Finland and the Netherlands	1 no difference (n=187) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Li, 2021 ⁶⁰	SPPB Whey Protein (whey protein blended supplement), soy protein (soy protein blended supplement), whey-Soy protein group (1:1 ratio of whey and soy blended supplement) vs control (no supplementation)	Individuals recruited from China	1 found benefit (n=123) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Muscle Strength										
Backx, 2016 ⁵⁶	Handgrip strength High protein diet (contain 1.7g of protein/Kg/day) vs normal protein diet (contain 0.9 g protein/Kg/day)	Individuals recruited from the Netherlands	1 no difference (n=60) 12 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
Li, 2021 ⁶⁰	Handgrip strength Whey Protein (whey protein blended supplement), soy protein (soy protein blended supplement), whey-Soy protein group (1:1 ratio of whey and soy blended supplement) vs control (no supplementation)	Individuals recruited from China	1 no difference (n=123) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Reinders, 2022 ⁶¹	Handgrip strength Protein advice (advised to increase protein intake to ≥ 1.2 g/kg aBW/d) vs control (no advice to increase protein consumption)	Individuals recruited from Finland and the Netherlands	1 no difference (n=187) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Zhu, 2015 ⁶⁴	Handgrip strength High Protein (supplement drink - 30 g of protein per day) vs placebo supplement (high-	Individuals recruited from Australia	1 no difference (n=181) 2 years	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	carbohydrate drink supplement drink - 2.1 g of protein per day)									
Englert, 2021 ⁵⁷	Handgrip strength High Protein (1.5 g/kg body weight) vs normal protein (0.8 g/kg body weight)	Individuals recruited from Germany	1 found benefit (n=54) 12 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Backx, 2016 ⁵⁶	1-RM leg press High protein diet (contain 1.7g of protein/Kg/day) vs normal protein diet (contain 0.9 g protein/Kg/day)	Individuals recruited from the Netherlands	1 no difference (n=53) 12 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Zhu, 2015 ⁶⁴	Knee flexor strength High Protein (supplement drink - 30 g of protein per day) vs placebo supplement (high-carbohydrate drink supplement drink - 2.1 g of protein per day)	Individuals recruited from Australia	1 no difference (n=181) 2 years	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Backx, 2016 ⁵⁶	Leg extensor strength (1-RM leg extension)	Individuals recruited from the	1 no difference (n=53) 12 weeks	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	High protein diet (contain 1.7g of protein/Kg/day) vs normal protein diet (contain 0.9 g protein/Kg/day)	Netherlands								conclusion
Zhu, 2015 ⁶⁴	Leg extensor strength (knee extensor strength) High Protein (supplement drink - 30 g of protein per day) vs placebo supplement (high-carbohydrate drink supplement drink - 2.1 g of protein per day)	Individuals recruited from Australia	1 no difference (n=181) 2 years	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Reinders, 2022 ⁶¹	Leg extensor strength Protein advice (advised to increase protein intake to ≥ 1.2 g/kg aBW/d) vs control (no advice to increase protein consumption)	Individuals recruited from Finland and the Netherlands	1 found benefit (n=187) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Smith, 2018 ⁶²	Sum 1-RM strength Weight loss plus whey protein	Individuals recruited from U.S.	1 no difference (n=52) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	supplement (hypocaloric diet with increased protein intake 1.2 g/kg/d) vs weight loss plus recommended protein (hypocaloric diet with 0.8 g/kg/d protein)									
Smith, 2018 ⁶²	Sum knee extension peak torque Weight loss plus whey protein supplement (hypocaloric diet with increased protein intake 1.2 g/kg/d) vs weight loss plus recommended protein (hypocaloric diet with 0.8 g/kg/d protein)	Individuals recruited from U.S.	1 no difference (n=52) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion
Smith, 2018 ⁶²	Sum knee flexion peak torque Weight loss plus whey protein supplement (hypocaloric diet with increased protein intake 1.2 g/kg/d) vs weight loss plus	Individuals recruited from U.S.	1 no difference (n=52) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Imprecise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Author, Year	Outcome Comparisons	Population	Findings (n analyzed) Timing	Limitations*	Directness	Study Consistency	Precision Reporting	Reporting Bias	Grade	Conclusion
	recommended protein (hypocaloric diet with 0.8 g/kg/d protein)									
Li, 2021 ⁶⁰	Chair stand Whey Protein (whey protein blended supplement), soy protein (soy protein blended supplement), whey-Soy protein group (1:1 ratio of whey and soy blended supplement) vs control (no supplementation)	Individuals recruited from China	1 found benefit (n=123) 6 months	1 RCT Low risk: 1	Direct	Unknown (single study)	Precise	NA	Insufficient	Insufficient evidence on which to draw a conclusion

Abbreviations: aBW = adjusted body weight; BIA = bioelectrical impedance analysis; d = day; DXA = dual-energy X-ray absorptiometry; g = gram(s); kg = kilogram(s); n = number analyzed; NA = not applicable; NR = not reported; RCT = randomized controlled trial; RM = repetition maximum; SoE = strength of evidence; SPPB = Short physical performance battery; TUG = Timed Up-and-Go; FFM = fat free mass; U.S. = United States

Note: *Includes study design and RoB score, **: Studies overlap KQs, *** Baseline characteristics were presented for participants who completed the 52-week intervention; but intention-to-treat evaluation was conducted for the full sample.

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