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Athletes: The Impact of High-Protein Diets on Overall Health, Body Composition, and Metabolic Function: A Narrative Review

Siatkowska Karolina

ORCID <https://orcid.org/0009-0003-0581-0010>

E-mail: siatkowskarolina@gmail.com

Warszawska Stomatologia, Warsaw, Poland

Pawlak Stanisław

ORCID <https://orcid.org/0009-0009-8640-7429>

E-mail: s.pawlak@me.com

Warszawska Stomatologia, Warsaw, Poland

Moroz Agata

ORCID <https://orcid.org/0009-0001-2720-6696>

E-mail: agata.moroz05@gmail.com

Abstract

Background. While high-protein diets are traditionally viewed through the lens of muscle hypertrophy, their systemic impact on broad health parameters, weight management, and metabolic stability across active populations demands reevaluation. Misconceptions regarding potential renal and skeletal risks frequently obscure the evidence-based benefits of elevated protein intake.

Aim. This review aimed to synthesize literature concerning the systemic impact of high-protein dietary protocols on body composition, metabolic thermogenesis, satiety regulation, and physiological safety markers in healthy adults.

Material and methods: Core clinical nutrition and sports science databases were reviewed for trials and meta-analyses investigating dietary protein intakes ranging from RDA baseline (0.8 g/kg/d) up to high-dose protocols (1.2 to >4.4 g/kg/d) and their chronic markers of metabolic, renal, skeletal, and cardiovascular health.

Results: Elevated protein protocols significantly augment muscle protein synthesis, preserve lean mass during energy deficit, and prevent non-functional fat accumulation under hypercaloric conditions. High protein intake enhances postprandial thermogenesis and modulates appetite-regulating satiety pathways. Meta-analytic data confirm chronic high-protein consumption does not compromise renal filtration, bone mineral density, or lipid profiles in healthy individuals.

Conclusions. High-protein dietary regimens represent a safe, multi-systemic strategy for active individuals. Elevated protein intake functions as a primary metabolic modulator that optimizes body composition, supports cellular recovery, and maintains long-term systemic stability without inducing renal or skeletal toxicity.

Keywords: high-protein diet, body composition, muscle protein synthesis, renal function, thermogenesis, systematic recovery, sports nutrition

Introduction

Dietary protein represents one of the three primary macronutrients essential for human physiological function, serving as a structural framework for cellular components, enzymatic reactions, hormonal signaling, and immune defenses. Over the past several decades, the recommended dietary allowance (RDA) for protein has been established at 0.8 grams per kilogram of body weight per day (g/kg/d) for adults [11]. This guideline was originally derived from nitrogen balance studies designed to determine the minimum intake required to prevent overt deficiency states and muscular wasting in sedentary populations [11]. However, accumulating clinical and epidemiological evidence suggests that the optimal protein intake for health maintenance, physical performance, metabolic efficiency, and tissue repair significantly exceeds these baseline recommendations, particularly among physically active individuals, athletes, and elderly cohorts seeking to preserve functional capacity [6, 11, 20].

In contemporary sports science and clinical nutrition, high-protein diets are typically defined as those providing protein intakes between 1.2 g/kg/d and upwards of 3.0 to 4.4 g/kg/d, or providing more than 20 percent to 35 percent of total daily energy intake [1, 3, 4, 6]. The resurgence of interest in elevated dietary protein has been driven by its potential benefits in facilitating fat mass loss, preserving lean muscle mass during energy restriction, augmenting muscle hypertrophic adaptations to resistance exercise, and enhancing satiety and glycemic management [7, 8, 9, 21, 22]. Furthermore, hypercaloric high-protein diets have demonstrated unique properties regarding nutrient partitioning, wherein extreme protein intakes do not lead to significant fat mass accumulation despite positive energy balance [1, 3, 10].

Despite widespread adoption across athletic and fitness domains, high-protein dietary regimens remain the subject of persistent scientific debate and clinical caution [12, 16]. Concerns historically raised by health professionals center around potential adverse impacts on renal function, skeletal mineral density, cardiovascular health, and systemic metabolic homeostasis [5, 13, 16]. Specifically, hypotheses regarding glomerular hyperfiltration, renal hyperperfusion, hypercalciuria-induced bone resorption, and unfavorable altered lipid profiles have frequently been cited as cautionary risks [12, 16]. Nevertheless, modern systematic reviews and longitudinal randomized controlled trials have increasingly challenged these traditional paradigms, pointing to a lack of empirical evidence supporting detrimental outcomes in healthy, resistance-trained individuals or active adult cohorts [1, 2, 5, 12, 13, 14, 15].

The primary objective of this narrative review is to evaluate the comprehensive impact of high-protein diets on overall health, skeletal muscle dynamics, body composition, and metabolic

biomarkers. By synthesizing current empirical findings, randomized clinical trials, and meta-analytic evidence, this paper examines the physiological mechanisms underlying protein-induced thermogenesis, satiety regulation, muscle protein synthesis, renal filtration adaptations, and bone turnover dynamics. Through this structured synthesis, the review aims to provide evidence-based insights for sports nutrition practitioners, clinical researchers, and active individuals seeking to optimize health outcomes and athletic performance through strategic dietary intervention.

2. Materials and Methods

2.1. Search Strategy and Data Sources

To evaluate how elevated dietary protein intake impacts overall health, body composition, and metabolic homeostasis, a comprehensive literature search was conducted across international scientific databases, including PubMed, Web of Science, Scopus, and Google Scholar. The search focused on peer-reviewed research published up to 2026.

Search queries combined key terms related to:

- **Protein intake and body composition:** high-protein diet, muscle protein synthesis, lean mass preservation, fat mass loss, hypercaloric diet, nutrient partitioning.
- **Metabolism and thermogenesis:** diet-induced thermogenesis, satiety regulation, peptide YY, GLP-1, ghrelin, glucose homeostasis, insulin sensitivity.
- **Organ-specific health and biomarkers:** renal function, glomerular filtration rate, blood urea nitrogen, bone mineral density, hypercalciuria, blood lipid profiles.

2.2. Selection Criteria

Studies were selected based on clear inclusion and exclusion criteria to ensure the evidence directly answered the research objectives.

Category	Included Studies	Excluded Studies
Study Population	Healthy active adults, resistance-trained individuals, and clinical cohorts evaluated for body composition or metabolic outcomes [1, 2, 5, 21, 22].	Populations with pre-existing chronic kidney disease, severe metabolic pathology, or end-stage renal failure.

Interventions	High-protein dietary regimens ranging from 1.2 g/kg/d to hypercaloric protocols up to 4.4 g/kg/d [3, 4, 6].	Studies lacking defined dietary protein quantification or evaluating uncontrolled multi-ingredient supplements.
Measured Outcomes	Muscle protein synthesis rate, body fat percentage, GFR, bone mineral density (BMD), lipid biomarkers, and satiety measures [7, 9, 12, 13, 18].	Articles lacking objective physiological biomarkers, quantitative dietary tracking, or peer-reviewed publication status.

Table 1. Inclusion and exclusion criteria for literature synthesis.

2.2 AI

AI was utilized for two specific purposes in this research. Text analysis of clinical reasoning narratives to identify linguistic patterns associated with specific logical fallacies. Assistance in refining the academic English language of the manuscript, ensuring clarity, consistency, and adherence to scientific writing standards. AI were used for additional linguistic refinement of the research manuscript, ensuring proper English grammar, style, and clarity in the presentation of results. It is important to emphasize that all AI tools were used strictly as assistive instruments under human supervision. The final interpretation of results, classification of errors, and conclusions were determined by human experts in clinical medicine and formal logic. The AI tools served primarily to enhance efficiency in data processing, pattern recognition, and linguistic refinement, rather than replacing human judgment in the analytical process.

3. Results

The systematic literature synthesis revealed consistent multi-systemic adaptations to elevated dietary protein consumption across body composition, muscle tissue dynamics, energy expenditure, organ-specific functional safety, and metabolic homeostasis.

3.1. Body Composition, Muscle Protein Synthesis, and Nutrient Partitioning

The literature demonstrates that dietary protein intake exceeding the baseline Recommended Dietary Allowance (RDA) of 0.8 g/kg/d yields superior improvements in body composition

under both energy-restricted and hypercaloric conditions [7, 8, 21]. During energy deficit, higher protein consumption (ranging from 1.6 to 2.4 g/kg/d) significantly attenuates the loss of lean tissue while accelerating body fat mass reduction compared to standard protein control diets [7, 8, 10, 21].

In resistance-trained populations, systematic review and meta-analytic evidence indicates that daily protein intakes between 1.6 g/kg/d and 2.2 g/kg/d optimize resistance training-induced gains in muscle mass and strength [6, 9]. Muscle protein synthesis (MPS) studies highlight that the intracellular stimulation of the mechanistic target of rapamycin complex 1 (mTORC1) pathway is maximized when protein is distributed evenly throughout the day in doses containing approximately 2.5 to 3.0 grams of leucine [6, 18]. Lower-quality or incomplete protein sources fail to stimulate 24-hour MPS to the same extent as high-quality complete proteins unless consumed in larger, leucine-supplemented volumes [19].

When evaluating extreme hypercaloric conditions, longitudinal clinical trials in resistance-trained males revealed unique nutrient partitioning dynamics [1, 3, 4]. Intakes as high as 3.4 g/kg/d to 4.4 g/kg/d over multi-week intervention periods did not result in additional body fat accumulation, despite participants exceeding their normal daily energy baseline by over 500 kcal per day [1, 3, 4]. This indicates a marked metabolic inefficiency in converting excess amino acids into stored triglycerides compared to excess dietary carbohydrates or fats [1, 7, 10].

3.2. Thermogenesis, Appetite Modulation, and Glycemic Homeostasis

High-protein dietary interventions consistently produced elevated postprandial energy expenditure via diet-induced thermogenesis (DIT) [10, 17]. The thermic effect of protein accounts for approximately 20% to 30% of its total caloric value, which is substantially higher than the thermic costs of carbohydrates (5% to 10%) or lipids (0% to 3%) [10, 17].

Simultaneously, elevated protein intake exerted a strong satiating effect mediated by key neuroendocrine gut peptides [8, 10, 16]. Higher protein ingestion suppressed circulating levels of the orexogenic hormone ghrelin while stimulating anorexigenic signals, including peptide YY (PYY) and glucagon-like peptide-1 (GLP-1) [8, 10, 16]. In clinical trials involving overweight and obese adult females undergoing weight loss, higher dietary protein-to-carbohydrate ratios yielded significant improvements in glycemic management, characterized by reduced fasting glucose, lower baseline insulin concentrations, and stabilized postprandial insulin resistance markers [21, 22]. These glycemic benefits occurred alongside favorable shifts

in serum lipid biomarkers, including reductions in circulating triglycerides and stabilization of high-density lipoprotein (HDL) profiles [21].

3.3. Renal Safety and Filtration Adaptation

Meta-analyses and longitudinal crossover studies in subjects without pre-existing chronic kidney disease (CKD) failed to demonstrate any adverse impacts of high-protein diets on renal architecture or function [2, 5, 12]. In systematic reviews comparing higher-protein diets (exceeding 1.5 g/kg/d) with standard or low-protein diets, differences in estimated glomerular filtration rate (eGFR) and blood urea nitrogen (BUN) reflected normal physiological hyperfiltration rather than pathological nephron decay or chronic hyperperfusion injury [2, 5, 12, 13].

Furthermore, long-term intervention trials examining resistance-trained athletes who consumed high-protein diets (2.5 g/kg/d to >3.0 g/kg/d) over a full one-year period showed no significant clinical alterations in serum creatinine, blood urea clearance, or urinalysis markers of kidney injury [1, 2]. Clinical parameters remained within standard reference intervals, confirming that high-protein intake induces a benign functional reserve response in individuals with healthy renal physiology [1, 2, 5, 12].

3.4. Skeletal Homeostasis and Bone Mineral Density

Evidence from meta-analyses sponsored by the National Osteoporosis Foundation systematically refuted the historical "acid-ash hypothesis," which posited that protein-induced metabolic acidosis promotes skeletal calcium leaching and reduced bone density [13, 14, 15, 16]. While elevated protein intake increased urinary calcium excretion, tracer and metabolic studies confirmed that this hypercalciuria was offset by a concurrent increase in fractional intestinal calcium absorption [10, 13, 19].

Randomized controlled trials and meta-analytic data indicated that higher protein consumption exerts a neutral-to-positive effect on bone mineral density (BMD) at critical skeletal sites, including the lumbar spine, femoral neck, and total hip [13, 14, 15]. Subgroup analyses comparing animal-derived protein with plant-derived protein sources demonstrated no detrimental divergence in bone density or fracture risk, provided overall calcium intake remained adequate [14, 15]. Additionally, elevated protein intake stimulated circulating insulin-like growth factor-1 (IGF-1), an essential promoter of osteoblast proliferation and bone matrix formation [10, 13, 15].

4. Discussion

The synthesis of contemporary empirical literature reveals that elevated dietary protein consumption exerts profound multi-systemic effects that challenge traditional nutritional paradigms. Historically, recommended dietary allowances (RDA) of 0.8 g/kg/d were established primarily to prevent nitrogen deficit and overt muscular atrophy in sedentary populations [11]. However, modern sports science and clinical nutrition data consistently demonstrate that this baseline threshold is insufficient for optimizing physical performance, body composition, and metabolic homeostasis in physically active individuals [6, 11, 20].

The comprehensive physiological adaptations, metabolic outcomes, and organ-specific safety markers across varying protein intake tiers are synthesized in Table 2.

Protein Intake Tier	Primary Metabolic & Body Composition Adaptation	Renal & Skeletal Health Markers	Key References
Standard RDA (~0.8 g/kg/d)	Maintains baseline nitrogen balance; minimal support for muscle hypertrophy or fat loss.	Standard baseline eGFR and normal bone turnover.	[11, 20]
Optimal Performance (1.6 – 2.4 g/kg/d)	Maximizes muscle protein synthesis (mTORC1); preserves lean mass; enhances thermogenesis and satiety.	Physiological adaptive hyperfiltration; neutral-to-positive bone mineral density (BMD).	[6, 7, 8, 9, 13, 18, 21]
Extreme Hypercaloric (>3.0 – 4.4 g/kg/d)	Plateaus muscle synthesis; prevents excess body fat accumulation via unique nutrient partitioning.	No clinical impairment of eGFR, creatinine, or kidney biomarkers in healthy adults.	[1, 2, 3, 4, 5, 12]

Table 2. Summary of physiological effects across different dietary protein intake levels.

4.1. Body Composition, Muscle Protein Synthesis, and Nutrient Partitioning

The impact of high-protein dietary protocols on body composition is mediated through distinct metabolic and endocrine pathways. During energy restriction, higher protein intakes prevent lean mass loss while accelerating body fat oxidation [7, 8, 21]. This effect is largely driven by the preservation of skeletal muscle tissue, which sustains basal metabolic rate during periods of negative energy balance [7, 8, 10].

In resistance-trained populations, consuming protein at levels between 1.6 and 2.2 g/kg/d provides the requisite essential amino acids, particularly leucine, to maximize 24-hour muscle protein synthesis (MPS) via the mechanistic target of rapamycin complex 1 (mTORC1) pathway [6, 9, 18, 20]. Research investigating hypercaloric high-protein diets (3.4 to 4.4 g/kg/d) in resistance-trained athletes demonstrates a unique nutrient partitioning effect: despite consuming substantial caloric surpluses, subjects fail to accumulate additional fat mass while continuing to gain lean body mass [1, 3, 4]. This outcome highlights the metabolic inefficiency of converting excess protein into stored adipose tissue compared to other macronutrients [1, 7, 10].

4.2. Metabolic Thermogenesis and Neuroendocrine Satiety Dynamics

The metabolic advantages of high-protein diets are closely linked to diet-induced thermogenesis (DIT). Protein intake triggers a significantly greater postprandial thermic effect (20% to 30% of ingested energy) compared to carbohydrates (5% to 10%) and fats (0% to 3%), owing to the high energetic cost of peptide bond breakdown, hepatic urea synthesis, and gluconeogenesis [10, 17]. This elevated thermogenesis contributes directly to enhanced daily energy expenditure [7, 8, 10].

Simultaneously, high-protein intake promotes satiety via modulation of gut-derived appetite signals, specifically suppressing circulating ghrelin while stimulating peptide YY (PYY) and glucagon-like peptide-1 (GLP-1) [8, 10, 16, 17]. These neuroendocrine adaptations mitigate compensatory overeating, improving long-term dietary adherence during weight-reduction regimens [7, 8, 21]. Furthermore, high-protein, lower-carbohydrate protocols attenuate postprandial glycemic excursions, supporting glycemic stability and insulin sensitivity [8, 21, 22].

4.3. Renal Function and Nephrological Considerations

For decades, elevated dietary protein was hypothesized to induce progressive renal damage via persistent glomerular hyperfiltration, increased intraglomerular pressure, and elevated blood

urea nitrogen clearance demands [5, 12, 13, 16]. While hyperfiltration represents an early pathological feature in chronic kidney disease (CKD), contemporary systematic reviews and meta-analyses establish that it constitutes a normal, adaptive physiological response in individuals with healthy renal architecture [2, 5, 12].

Longitudinal crossover trials and meta-analytic evidence confirm that chronic protein intakes exceeding 3.0 g/kg/d over extended periods do not impair estimated glomerular filtration rate (eGFR), serum creatinine, or urinary albumin excretion in healthy adults [1, 2, 5, 12]. The physiological hyperfiltration observed during high protein loading reflects functional renal reserve rather than structural nephron damage [5, 12, 13]. Consequently, clinical guidelines cautioning against high protein consumption due to kidney toxicity remain unsupported by empirical evidence in non-CKD populations [2, 5, 12, 16].

4.4. Skeletal Homeostasis and Bone Mineral Density

Historical concerns regarding high-protein diets inducing metabolic acidosis and subsequent osteoclastic bone resorption—the "acid-ash hypothesis"—have been systematically refuted [10, 13, 14, 15, 16]. While protein ingestion increases urinary calcium excretion, this hypercalciuria does not reflect skeletal calcium leaching [13, 16, 19]. Rather, elevated amino acid availability enhances intestinal calcium absorption, leading to a net positive or neutral whole-body calcium balance [10, 13, 19].

Furthermore, dietary protein stimulates hepatic secretion of insulin-like growth factor-1 (IGF-1), a hormone critical for osteoblast proliferation, collagen matrix synthesis, and bone mineralization [10, 13, 15]. Systematic reviews and meta-analyses published by the National Osteoporosis Foundation confirm that higher protein intakes—derived from both animal and plant sources—exert neutral-to-beneficial effects on bone mineral density (BMD) and are associated with reduced fracture risk at key skeletal sites [13, 14, 15].

4.5. Practical Implications and Recommendations

The current body of evidence indicates that high-protein diets ranging from 1.6 to 2.4 g/kg/d are safe, tolerable, and highly effective for physically active individuals, athletes, and adults seeking weight management or preservation of muscle mass [1, 2, 6, 8, 20]. Protein distribution across the day also plays a key role, with evenly distributed moderate doses (~0.4 g/kg per meal) optimizing 24-hour MPS compared to skewed intake patterns [18, 19].

While acute intakes up to 4.4 g/kg/d have been documented without adverse clinical outcomes in resistance-trained men [3], such extreme intakes offer diminishing returns for muscle

hypertrophy and may displace other essential dietary components, such as dietary fiber and micronutrients [6, 9, 12, 20]. Therefore, personalized dietary strategies should balance high protein goals with whole-food sources, adequate hydration, and balanced micronutrient intake to optimize overall systemic health and athletic performance [6, 12, 20].

5. Conclusions

High-protein dietary regimens represent a safe, multi-systemic nutritional approach that delivers substantial physiological benefits for physically active adults, athletes, and individuals undergoing weight management [1, 6, 8, 20]. Current evidence strongly indicates that protein requirements for optimizing health, body composition, and physical capacity extend well beyond the standard Recommended Dietary Allowance (RDA) of 0.8 g/kg/d [6, 11, 20].

The clinical and practical findings of this review lead to the following key conclusions:

1. **Optimization of Body Composition and Muscle Mass:** Dietary protein intakes ranging between 1.6 g/kg/d and 2.4 g/kg/d maximize muscle protein synthesis, accelerate fat mass reduction, and effectively preserve lean body tissue during energy restriction [6, 7, 8, 21]. Under hypercaloric conditions, extreme protein intakes (up to 3.4–4.4 g/kg/d) prevent non-functional fat mass accumulation via unique nutrient partitioning dynamics [1, 3, 4].
2. **Metabolic and Satiety Regulation:** High protein ingestion increases daily energy expenditure through elevated diet-induced thermogenesis and promotes long-term appetite control by suppressing ghrelin while stimulating peptide YY and GLP-1 [8, 10, 16, 17]. It also supports favorable glycemic control and lipid profiles [21, 22].
3. **Renal and Skeletal Safety:** In individuals with healthy baseline physiology, chronic high-protein consumption does not induce adverse renal effects or impair glomerular filtration [2, 5, 12]. Furthermore, high-protein intake exerts neutral-to-positive effects on bone mineral density without accelerating skeletal resorption, supported by enhanced intestinal calcium absorption and elevated circulating IGF-1 [10, 13, 14, 15].

Overall, increasing daily dietary protein is a highly effective intervention for enhancing physiological performance, optimizing body composition, and maintaining systemic metabolic stability in healthy adults [1, 6, 12, 20].

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Author's contribution: KS

Conceptualization: KS; SP: AM

Methodology: AM

Software AM

Check: SP; AM

Formal analysis: KS

Investigation: KS

Resources: KS; SP

Data curation: KS

Writing- rough preparation: KS

Writing- review and editing: SP

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References

1. Antonio, J., Ellerbroek, A., Silver, T., Vargas, L., Tamayo, A., Buehn, R., & Peacock, C. A. (2016). A High Protein Diet Has No Harmful Effects: A One-Year Crossover Study in Resistance-Trained Males. *Journal of Nutrition and Metabolism*, 2016, 9104792. <https://doi.org/10.1155/2016/9104792>
2. Antonio, J., Ellerbroek, A., Silver, T., Vargas, L., & Peacock, C. (2016). The effects of a high protein diet on indices of health and body composition – a crossover trial in resistance-trained men. *Journal of the International Society of Sports Nutrition*, 13(1), 3. <https://doi.org/10.1186/s12970-016-0114-2>
3. Antonio, J., Peacock, C. A., Ellerbroek, A., Fromhoff, B., & Silver, T. (2014). The effects of consuming a high protein diet (4.4 g/kg/d) on body composition in resistance-

- trained individuals. *Journal of the International Society of Sports Nutrition*, 11(1), 19. <https://doi.org/10.1186/1550-2783-11-19>
4. Ellerbroek, A., Peacock, C. A., Orris, S., Scheiner, M., Gonzalez, A., Silver, T., & Antonio, J. (2015). The effects of heavy resistance training and a high protein diet (3.4g/kg/d) on body composition, exercise performance and indices of health in resistance-trained individuals - a follow-up investigation. *Journal of the International Society of Sports Nutrition*, 12(Suppl 1), P37. <https://doi.org/10.1186/1550-2783-12-s1-p37>
 5. Devries, M. C., Sithamparampillai, A., Brimble, K. S., Banfield, L., Morton, R. W., & Phillips, S. M. (2018). Changes in Kidney Function Do Not Differ between Healthy Adults Consuming Higher- Compared with Lower- or Normal-Protein Diets: A Systematic Review and Meta-Analysis. *The Journal of Nutrition*, 148(11), 1760–1775. <https://doi.org/10.1093/jn/nxy197>
 6. Jäger, R., Kerksick, C. M., Campbell, B. I., Cribb, P. J., Wells, S. D., Skwiat, T. M., Purpura, M., Ziegenfuss, T. N., Ferrando, A. A., Arent, S. M., Smith-Ryan, A. E., & Stout, J. R. (2017). International Society of Sports Nutrition Position Stand: protein and exercise. *Journal of the International Society of Sports Nutrition*, 14(1), 20. <https://doi.org/10.1186/s12970-017-0177-8>
 7. Leidy, H. J., Clifton, P. M., Astrup, A., Wycherley, T. P., Westerterp-Plantenga, M. S., Luscombe-Marsh, N. D., Woods, S. C., & Mattes, R. D. (2015). The role of protein in weight loss and maintenance. *The American Journal of Clinical Nutrition*, 101(6), 1320S–1329S. <https://doi.org/10.3945/ajcn.114.084038>
 8. Moon, J., & Koh, G. (2020). Clinical Evidence and Mechanisms of High-Protein Diet-Induced Weight Loss. *Journal of Obesity & Metabolic Syndrome*, 29(3), 166–173. <https://doi.org/10.7570/jomes20028>
 9. Morton, R. W., Murphy, K. T., McKellar, S. R., Schoenfeld, B. J., Henselmans, M., Helms, E., Aragon, A. A., Devries, M. C., Banfield, L., Krieger, J. W., & Phillips, S. M. (2018). A systematic review, meta-analysis and meta-regression of the effect of protein supplementation on resistance training-induced gains in muscle mass and strength in healthy adults. *British Journal of Sports Medicine*, 52(6), 376–384. <https://doi.org/10.1136/bjsports-2017-097608>
 10. Pesta, D. H., & Samuel, V. T. (2014). A high-protein diet for reducing body fat: mechanisms and possible caveats. *Nutrition & Metabolism*, 11(1), 53. <https://doi.org/10.1186/1743-7075-11-53>

11. Phillips, S. M., Chevalier, S., & Leidy, H. J. (2016). Protein “requirements” beyond the RDA: implications for optimizing health. *Applied Physiology, Nutrition, and Metabolism*, 41(5), 565–572. <https://doi.org/10.1139/apnm-2015-0550>
12. Schwingshackl, L., & Hoffmann, G. (2014). Comparison of High vs. Normal/Low Protein Diets on Renal Function in Subjects without Chronic Kidney Disease: A Systematic Review and Meta-Analysis. *PLoS ONE*, 9(5), e97656. <https://doi.org/10.1371/journal.pone.0097656>
13. Shams-White, M. M., Chung, M., Du, M., Fu, Z., Insogna, K. L., Karlsen, M. C., LeBoff, M. S., Shapses, S. A., Sackey, J., Wallace, T. C., & Weaver, C. M. (2017). Dietary protein and bone health: a systematic review and meta-analysis from the National Osteoporosis Foundation. *The American Journal of Clinical Nutrition*, 105(6), 1528–1543. <https://doi.org/10.3945/ajcn.116.145110>
14. Shams-White, M. M., Chung, M., Fu, Z., Insogna, K. L., Karlsen, M. C., LeBoff, M. S., Shapses, S. A., Sackey, J., Shi, J., Wallace, T. C., & Weaver, C. M. (2018). Animal versus plant protein and adult bone health: A systematic review and meta-analysis from the National Osteoporosis Foundation. *PLOS ONE*, 13(2), e0192459. <https://doi.org/10.1371/journal.pone.0192459>
15. Shams-White, M., Sackey, J., Fu, Z., Karlsen, M., Du, M., Insogna, K., LeBoff, M., Shapses, S., Weaver, C., & Chung, M. (2016). Protein Intake and Bone Mineral Density- a Systematic Review and Meta-Analysis of Randomized Controlled Trials. *The FASEB Journal*, 30(S1), 678.6. https://doi.org/10.1096/fasebj.30.1_supplement.678.6
16. Cuenca-Sánchez, M., Navas-Carrillo, D., & Orenes-Piñero, E. (2015). Controversies Surrounding High-Protein Diet Intake: Satiating Effect and Kidney and Bone Health. *Advances in Nutrition*, 6(3), 260–269. <https://doi.org/10.3945/an.114.007716>
17. Halton, T. L., & Hu, F. B. (2004). The Effects of High Protein Diets on Thermogenesis, Satiety and Weight Loss: A Critical Review. *Journal of the American College of Nutrition*, 23(5), 373–385. <https://doi.org/10.1080/07315724.2004.10719381>
18. Mamerow, M. M., Mettler, J. A., English, K. L., Casperson, S. L., Arentson-Lantz, E., Sheffield-Moore, M., Layman, D. K., & Paddon-Jones, D. (2014). Dietary Protein Distribution Positively Influences 24-h Muscle Protein Synthesis in Healthy Adults. *The Journal of Nutrition*, 144(6), 876–880. <https://doi.org/10.3945/jn.113.185280>
19. Arentson-Lantz, E., Von Ruff, Z., Harvey, M., Wachter, A., & Paddon-Jones, D. (2021). A Moderate Serving of a Lower-Quality, Incomplete Protein Does Not Stimulate

Skeletal Muscle Protein Synthesis. *Current Developments in Nutrition*, 5(Suppl 2), 401.
https://doi.org/10.1093/cdn/nzab041_002

20. Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016). Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. *Journal of the Academy of Nutrition and Dietetics*, 116(3), 501–528. <https://doi.org/10.1016/j.jand.2015.12.006>
21. Layman, D. K., Boileau, R. A., Erickson, D. J., Painter, J. E., Shiue, H., Sather, C., & Christou, D. D. (2003). A Reduced Ratio of Dietary Carbohydrate to Protein Improves Body Composition and Blood Lipid Profiles during Weight Loss in Adult Women. *The Journal of Nutrition*, 133(2), 411–417. <https://doi.org/10.1093/jn/133.2.411>
22. Layman, D. K., Shiue, H., Sather, C., Erickson, D. J., & Baum, J. (2003). Increased Dietary Protein Modifies Glucose and Insulin Homeostasis in Adult Women during Weight Loss. *The Journal of Nutrition*, 133(2), 405–410. <https://doi.org/10.1093/jn/133.2.405>