Protein intake and bone health in the elderly

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Protein Intake and Bone Health in the Elderly

Proteinzufuhr und Knochengesundheit bei älteren Menschen

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ABSTRACT

Protein plays an important role in muscle and bone metabolism. This is of great importance for optimal bone health, especially in the elderly, in sarcopenia and osteoporosis. Adequate protein intake is a prerequisite for optimal musculoskeletal health and efficient strength training. Protein is one of the macronutrients and besides calcium the most abundant structural component of our musculoskeletal system. However, elderly subjects often consume too little protein. In 2017, the revised reference values in the D-A-CH region were increased for adults > 65 years to 1.0 g protein/kg (ideal) body weight [BW]/ day and ESPEN even advocates for an intake of 1.0–1.5 g protein/kg BW/ day. Many elderly people, especially women do not meet these targets. In our experience, there is a fundamental misconception that protein needs can only be met consuming animal products. Many studies have investigated whether sufficient protein intake has a positive effect on bone. In this short review, the importance of protein for bone and the problem of inadequate protein intake in sarcopenia will be discussed and the most relevant clinical guidelines and studies will be presented. For practical use, we give examples of omnivore and vegetarian meal plans and important protein sources (plant and animal origin) are given. Usually, the minimal demands can easily be met with simple nutritional advice. Sometimes however, additional protein supplements (often liquids, puddings, powders) are needed, especially in nursing home residents, and when poor appetite or dysphagia impair appropriate caloric and protein intake.

ZUSAMMENFASSUNG

Eiweiß spielt eine wichtige Rolle im Muskel- und Knochenstoffwechsel. Dies ist von großer Bedeutung für eine optimale Knochengesundheit, insbesondere bei älteren Menschen, bei Sarkopenie und Osteoporose. Eine ausreichende Proteinzufuhr ist eine Voraussetzung für eine optimale Gesundheit des Bewegungsapparats und ein effektives Krafttraining. Eiweiß ist einer der Makronährstoffe und neben Kalzium der am häufigsten vorkommende Strukturbestandteil unseres Bewegungsapparats. Ältere Menschen nehmen jedoch häufig zu wenig Eiweiß zu sich. Im Jahr 2017 wurden die überarbeiteten Referenzwerte in der D-A-CH-Region für Erwachsene > 65 Jahre auf 1,0 g Protein/kg (ideales) Körpergewicht [KG]/Tag angehoben und ESPEN plädiert sogar für eine Zufuhr von 1,0–1,5 g Protein/kg KG/Tag. Viele ältere Menschen, insbesondere Frauen, erreichen diese Ziele nicht. Unserer Erfahrung nach besteht ein grundlegender Irrglaube, dass der Proteinbedarf nur durch den Verzehr tierischer Produkte gedeckt werden kann. In vielen Studien wurde untersucht, ob sich eine ausreichende Proteinzufuhr positiv auf die Knochen auswirkt. In diesem kurzen Überblick wird die Bedeutung von Eiweiß für die Knochen und das Problem einer unzureichenden Eiweißzufuhr bei Sarkopenie erörtert, und es werden die wichtigsten klinischen Leitlinien und Studien vorgestellt. Für die Praxis werden Beispiele für omnivore und vegetarische Speisepläne gegeben und wichtige Proteinquellen (pflanzlichen und tierischen Ursprungs) genannt. In der Regel können die Mindestanforderungen mit einfachen Ernährungsempfehlungen leicht erfüllt werden.

Manchmal ist jedoch eine zusätzliche Eiweißergänzung (oft in flüssiger Form oder als Pudding oder Pulver) erforderlich, insbesondere bei Bewohnern von Pflegeheimen und wenn Appetitlosigkeit oder Schluckstörungen eine angemessene Kalorien- und Eiweißaufnahme beeinträchtigen.

Introduction

Protein, specifically collagen, is the major structural component of bone. Also, the bone turnover markers we measure in blood to assess bone turnover are proteins (ie.: Beta-CrossLaps are fragments of type-1-collagen). Osteogenesis imperfecta is an example of a genetic disease with high fracture risk and comprises several genetic disorders with impaired collagen production/metabolism.

Protein typically makes up for 10 to 35 % of caloric intake in healthy subjects. The protein leverage hypothesis suggests that most species including humans target an average protein intake of 14 % [1].

It is the most complex macronutrient, with a four-level structure as compared to the much simpler carbohydrates and fats. Protein composition is built from 20 amino acids, 9 of which are essential (histidine, isoleucine, leucine, lysine, threonine, methionine, phenylalanine, valine, tryptophan). Amino acids form polypeptides (i. e.: parathyroid hormone 1–34 or teriparatide consists of 34 amino acids) that form the primary structure of proteins.

Some proteins are made of as many as 30,000 amino acids – with varying percentages across different foods (and origin of protein – plant versus animal). Additionally, proteins form a secondary, tertiary and quaternary structure (the latter involving multiple polypeptide chains). Therefore, the digestion of proteins is more complicated and takes longer than the digestion of carbohydrates and fats.

This short narrative review aims to give an overview of this important non medication aspect of osteoporosis treatment.

In 2017, the revised reference values in the D-A-CH region were increased for adults > 65 years to 1.0 g protein/kg (ideal) body weight [BW]/ day [2]. Many elderly subjects do not meet these targets – for example, the large PROMISS project (Prevention of Malnutrition in Senior Subjects in the EU) using data from the Netherlands, Finland, Italy Canada, UK and USA showed that 46.7 % of community-dwelling older adults do not meet this cutoff (1.0 g/kg of body weight per day), with even higher percentages in some subgroups including women. In addition, 14–30 % had a protein intake below 0.8g/kg BW/d [3]. As bone consists to a large extent of proteins, it is reasonable to assume that adequate intake is important for bone health and fracture risk.

The direct effect of protein on bone is mainly due to the increase in IGF-1, which stimulates bone formation and leads to increased calcium absorption in the intestine. However, excessive intake of protein can paradoxically lead to an increased activity of osteoclast cells, which are responsible for the breakdown and remodelling of bone tissue [4]. The generally recommended optimal protein intake is at least 0.8 g/kilogram of body weight per day (DGE) for adults < 65 and > 1.0 above 65 [2]. For older people with acute or chronic illness even 1.2–1.5g/kg of body weight per day have been suggested in the ESPEN (European Society for Clinical Nutrition and Metabolism) practical guideline in 2022 [5].

Osteoporosis is linked to a person's lifestyle and eating behaviour. Especially in people over 65, bone mineral density can be affected by their diet [6]. Also, intestinal absorption and appetite decreases with age and the elderly become malnourished more quickly. Malnutrition is closely linked to the hypothalamic-pituitary-ovarian axis, which in turn strongly influences bone metabolism and can increase the risk for osteoporosis. It also has been shown that malnutrition leads to higher mortality [6].

Another disease that is strongly dependent on nutrition is sarcopenia (loss of skeletal muscle mass and strength). These two conditions frequently occur together. This is why the term "osteosarcopenia" is often used in this context. If both diseases occur at the same time, the risk for falls, fractures and mortality is significantly increased [7]. Older people (> 65 years) need sufficient protein in their diet and enough exercise to reduce their risk of sarcopenia and various disabilities. This works particularly well for people who are still independent in old age, including good cognition and a good social network [8].

How can the individual protein be adequately assessed?

The first step in ensuring that patients are consuming enough protein is to determine how much they are currently consuming. A simple food diary over a few days gives a clue whether this is the case (see ▶ **Tables 1–4** for examples). Nowadays it is also possible to track intake with many apps, which also give the estimated macronutrients. As most of them have very similar functions while availability and cost vary widely we would like to refrain from recommending any app. In general, apps are a good guide to how much of what has been eaten in a day. Certainly, the ideal option is to seek professional dietician advice, although this will often not be feasible.

Effects of protein intake on fracture risk

In a 2023 meta-analysis, the relationship between the intake of total protein, animal protein, fish and dairy products and the overall risk of fracture or hip fracture was investigated. It was found that a daily intake of at least 60–80g total protein appears to be associated with the lowest overall fracture risk (▶ **Fig. 1**). Although weight of the subjects was not given in this study, in our clinical experience, a typical female osteoporosis patient rarely weighs > 65 kg (most often 45–60kg, so 60g of protein would then correspond to 1.0–1.3g/kg, or 80g to 1.3–1.8g/kg which is consistent to the recommended intakes in elderly adults).

In statistical analyses, increasing the amount of total protein consumed by 100g/d reduced the fracture risk by 43 %, while an increased consumption of fish by 15g/d reduced this risk by 5 %. 100g/d more total protein led to a 48 % reduction in hip fracture risk, 100g/d more animal protein to a 50 % reduction and 15g/d more fish to a 5 % reduction. Interestingly, dairy products (milk, cheese, yoghurt) were not found to significantly reduce the general or hip fracture risk [9],

▶ **Table 1** Low protein, omnivore – depending on the weight of the subject, the RDA for protein in elderly men and women is not nearly met.

▶ **Tab. 1** Wenig Protein, omnivor – abhängig vom Gewicht der Person wird die empfohlene Tagesmenge für Protein bei älteren Männern und Frauen nicht annähernd erreicht.

	Food	Protein	Carbs	Fat	Energy
Breakfast	A bun with butter and jam, black coffee, orange juice (250ml)	8.5g	78.5g	18.4g	514kcal
Lunch	Sausage (frankfurter) with a bun and ketchup and mustard, milk chocolate (40g)	24.2g	62.7g	42g	733kcal
Snacks	Two bananas	3.4g	60.1g	0.5g	279kcal
Dinner	Green salad with pumpkin seed oil, 1 slice of white bread, an apple	4.1g	49.6g	15.6g	370kcal
		40g	**251g**	**77g**	**1897kcal**

▶ **Table 2** High protein, omnivore – depending on the weight of the subject, the RDA for protein in elderly men and women is easily met.

▶ **Tab. 2** Viel Protein, omnivor – abhängig vom Gewicht der Person wird die empfohlene Tagesmenge für Protein bei älteren Männern und Frauen leicht erreicht.

	Food	Protein	Carbs	Fat	Energy
Breakfast	Whole grain cheese toast (2 slices cheese), coffee with milk and protein powder	25.2g	27.4g	16.2g	356kcal
Lunch	1 tin of sardines with 2 slices whole-grain bread and olives, tomato salat with feta cheese (150g)	42.8g	45.5g	35g	690kcal
Snacks	Two handful of nut mix (60g)	7.8g	22.2g	15.6g	288kcal
Dinner	Omelette with 3 eggs topped with sesame, 2 slices of whole grain bread	26.8g	42g	26.1g	527kcal
		103g	**137g**	**93g**	**1861kcal**

▶ **Table 3** Low protein, vegetarian – depending on the weight of the subject, the RDA for protein in elderly men and women is not nearly met.

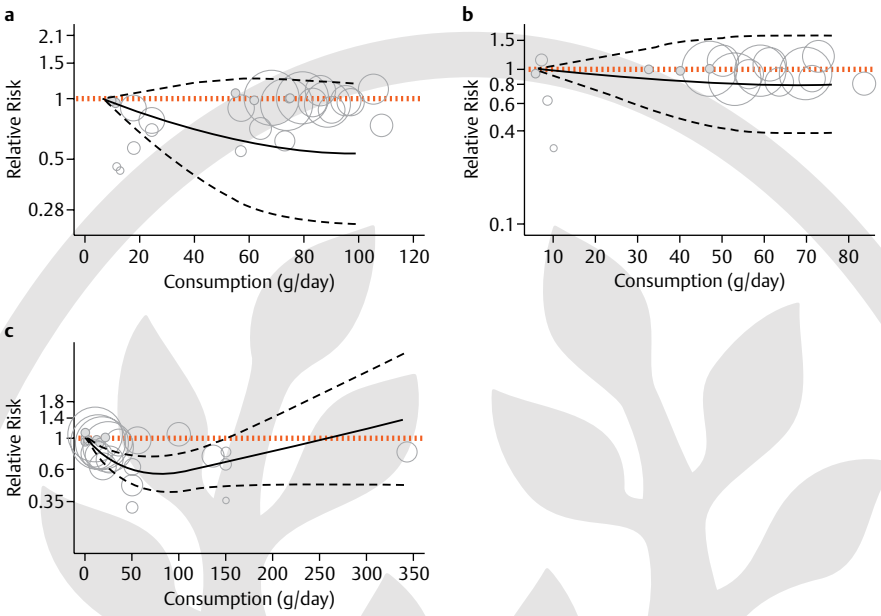
▶ **Tab. 3** Wenig Protein, vegetarisch – abhängig vom Gewicht der Person wird die empfohlene Tagesmenge für Protein bei älteren Männern und Frauen nicht annähernd erreicht.

	Food	Protein	Carbs	Fat	Energy
Breakfast	2 slices white bread with jam, black coffee	8g	62.9g	1.2g	302kcal
Lunch	White rice with vegetables, fruit salad	8.4g	97g	8.4g	622kcal
Snacks	One large banana, an apple, potato chips (30g)	4.6g	74.7g	10.4g	436kcal
Dinner	Green salad with tomatoes and 2 slices white bread	8.7g	56.7g	24g	479kcal
		30g	**291g**	**45g**	**1840kcal**

▶ **Table 4** High protein, vegetarian – depending on the weight of the subject, the RDA for protein in elderly men and women is easily met.

▶ **Tab. 4** Viel Protein, vegetarisch – abhängig vom Gewicht der Person wird die empfohlene Tagesmenge für Protein bei älteren Männern und Frauen leicht erreicht.

	Food	Protein	Carbs	Fat	Energy
Breakfast	2 slices whole-grain bread with cheese, coffee with milk and protein powder	28.4g	44.7g	15.5g	449kcal
Lunch	Lentil salad, whole-grain pasta with soy bolognese	44.6g	112.3g	8.1g	740kcal
Snacks	Two handful of almonds (50g)	12g	2.8g	26.5g	306kcal
Dinner	Greek yoghurt 2% with walnuts and honey	16.3g	24.5g	16.3g	391kcal
		101g	**184g**	**75g**	**1885kcal**



▶ **Fig. 1** Association between protein intake and the relative risk of suffering any fracture when considering **a** total protein, **b** animal protein and **c** protein in dairy products. It can be clearly seen that the risk of fracture decreases with increased protein intake. The optimal amount of protein from dairy products is therefore approx. 50g/d (according to [9]).

▶ **Abb. 1** Assoziation zwischen Proteinaufnahme und dem relativen Risiko irgendeine Fraktur zu erleiden unter Betrachtung von **a** Gesamtprotein, **b** tierisches Protein und **c** Eiweiß in Milchprodukten. Es ist klar zu erkennen, dass bei einer erhöhten Eiweißaufnahme das Frakturrisiko sinkt. Die optimale Menge an Protein aus Milchprodukten liegt demnach bei ca. 50g/d (Daten aus [9]).

On the other hand, Iuliano et al. showed in a landmark study that the addition of one milk product per day was able to significantly and substantially reduced fracture risk over two years in a cluster-randomized trial in Australian nursing homes. This one additional portion of milk, yoghurt or cheese increased protein intake by 12 (6) g and calcium intake by 562 (166) mg per day (or total 69 (15) g/day protein, 1142 (353) mg calcium – 1.1g/kg/BW) as opposed to the facilities maintaining their usual menu with residents consuming 700 (247) mg/day calcium and 58 (14) g/day protein (0.9 g/kg body weight) [10]. Although this study was not a pure protein intervention, the findings are highly relevant for clinical practice and thus, the addition of one more milk product per day can easily be recommended, allowing for personal preference (ie. cheese, yoghurt, milk, kefir, sour milk, cottage cheese etc.).

Other studies that looked at protein supplements in connection to bone have also produced positive results. One of these studies focussed on older people after an osteoporotic hip fracture. A significantly greater increase in IGF-1 was observed in comparison with a placebo group. Furthermore, the decrease in bone mass slowed down, the recovery from fracture was on average 21 days shorter and fewer new lumbar deformities were found [11].

In another study, although no difference in bone density was found at the end of the study period when taking a dietary supplement containing 45g whey protein per day, both lean body mass and serum levels of IGF-1 were significantly higher compared to the control group [12].

Yet another study suggested that the positive effects of a higher protein intake mainly occur in patients with a BMI over 30 and who are active. For other people, there is even an opposite effect. Plant protein performed better than total protein and animal protein. Bone mineral density and bone mineral content of the entire body as well as the femoral neck and lumbar spine were analysed [13].

The UK's NOGG (National Osteoporosis Guideline Group) guidelines from 2022 also state that sufficient protein intake is necessary to maintain the health of muscle and bone tissue. The positive effect of post-operative protein supplementation after hip fracture is particularly emphasized. It has been shown that this results in a shorter hospital stay with fewer infections. Protein intake above the recommended amount of 0.75g/kg of body weight per day is also considered. A meta-analysis is cited in which no significant changes in BMD were found with protein supplementation, as well as an RCT and several observational studies that establish a link between increased protein intake and higher BMD at the femoral neck and in the entire hip [14]. In one of these meta-analyses, a reduction in hip fractures was also found [15].

In a review for the evidence-based guideline of the German Nutrition Society it is stated that even though there are already a number of studies on this topic, more studies are still needed, especially with regard to the details of amount and type of protein. Protein intake above the recommended 1g/kg BW/d may have a beneficial effect on bone health in people over 65 years, as results suggest a reduced risk of hip fracture with a higher protein consumption [16].

▶ **Table 5** Protein content of selected plant-based foods [19] – *differences between trademarks exist.

▶ **Tab. 5** Proteingehalt ausgewählter pflanzlicher Lebensmittel [19] – *Es existieren Unterschiede abhängig vom Hersteller.

Food	Protein per 100g*	Serving size	Protein per portion
Soy granulate	52g	50g (dehydrated)	26g
Sunflower seeds	27g	1 tbsp	2.7g
Peanut butter	26g	1 tbsp	4g
Lentils raw/cooked	23g/8g	Main ingredient (100g/200g) side dish (60g/120g)	23g/16g 13.8g/9.6g
Protein bread	18g	1 slice (50g)	9g
Tempeh	17g	100g	17g
Walnuts	17g	Handful (30g)	5.1g
Quinoa	13g	Main ingredient (90g) side dish (50g)	11.7 6.5g
Chickpeas	6.7g	100g	6.7g
Broccoli	2,8g	Main ingredient (300–500g), side dish (~200g)	8.4–14 5.6g

▶ **Table 6** Protein content of selected animal foods [19] – *differences between trademarks exist.

▶ **Tab. 6** Proteingehalt ausgewählter tierischer Nahrungsmittel [19] – *Es existieren Unterschiede abhängig vom Hersteller.

Food	Protein per 100g*	Serving size	Protein per portion
Chicken filet	23g	160g	36.8g
Tuna	22g	One tin (165g)	36g
Beef	21g	Steak/cutlet (190g) processed – Bolognese, goulash (110g)	40g 23g
Sardines	20g	1 tin (~100g)	20g
Mozzarella	18g	125g	22.5g
Eggs	13g	1 egg	6–7g
Cottage cheese	11g	100–200g	11–22g
Greek yoghurt	6,6g	250g	16.5g
Regular yoghurt	4,1g	250g	10g
Butter milk 1 %	3,3g	250g	8.25g

Effects of a vegan diet on bone

A vegan diet completely lacks protein from animal foods such as dairy products and eggs and can lead to protein malnutrition more easily compared to an omnivore diet if basic knowledge is inexistent. A systematic review and meta-analysis from 2019 found that both vegan and vegetarian diets are linked to a lower BMD compared to an omnivore diet, which is more pronounced in older people and vegans. The lumbar spine and femoral neck are particularly affected. In addition, a higher fracture risk has been recognised in vegans (relative risk 1.44, 95 % confidence interval, 1.05–1.98). Proper prior planning and knowledge acquisition is therefore recommended before switching to one of these diets in order to avoid these negative effects. It was also noted that the effects described are not as pronounced in Asian people as in Caucasians. This was partially attributed to the higher consumption of soy products in Asia [17]. The EPIC-Oxford study from 2020 showed similar results. Vegans as well as fish eaters and vegetarians had a higher fracture risk, especially in the hip area. Furthermore, vegans also had a higher risk of fractures in other areas compared to omnivores. Overall, vegans and vegetarians in this study consumed less protein than omnivores. When the lower average BMI and the lower consumption of calcium and protein were taken into account, a difference remained, but it was smaller [18]. In a strict vegan diet, calcium intake is usually also lower.

Protein sources

There are some excellent sources of protein, many of which (e. g. tempeh) are rarely known to elderly patients but typically well liked. Also, foods that are very easy to prepare and do not require cooking, such as canned fish (sardine, mackerel), legumes or nuts can be an excellent, but often overlooked source of high-quality protein with a long shelf life.

As such, in many cases it is not absolutely necessary to resort to dietary supplements. In some cases the use of high quality protein may be preferable, for example whey protein is a milk-derived, easily available and inexpensive option. Below is a comparison of the protein content of some selected plant and animal foods ▶ **Tables 5, 6**.

However, it should be noted that the protein content can vary depending on the manufacturer. In addition, serving sizes may vary substantially from person to person.

Conclusion

An adequate intake of protein plays a major role for optimal bone health and is one of the prerequisites for conserving optimal muscle and bone health as well as for osteoporosis therapy. However, in our clinical experience osteoporosis patients often do not even meet the RDA of 0.8–1.0 g per kg ideal body weight. In the large international observational PROMISS study, low protein intake was especially common in women and those with poor appetite.

Many studies show that an adequate protein intake leads to a higher bone mineral density and reduces the risk of fractures. There are also already some positive studies on the benefits of higher

protein intake for bone. However, it is usually not necessary to use dietary supplements to get the recommended daily amount of protein. Often, simple nutritional advice can improve protein intake, using readily available plant and animal protein sources that can easily be incorporated into the existing dietary pattern. Particularly for patients with poor appetite or dysphagia, the use of neutral protein powder (whey or other sources) or other fortified products including special drinks or puddings are recommended. This can also be used to improve the protein content of commonly consumed drinks such as coffee or tea.

Key points

1. Protein is an important structural component of bone.
2. Bone turnover markers are proteins.
3. The lowest recommended daily intake for protein is > 0.8g/kg BW/d < 65 years and > 1g/kg BW/d for people > 65 years, corresponding to an absolute intake of 60–80g for many individuals. Some groups advocate an even higher RDA for elderly frail subjects.
4. Many elderly subjects especially women do not reach the daily minimal allowance.
5. Simple changes in the nutritional habits can have a large impact. Sometimes high quality protein powder may be helpful. Individual dietitian advice is needed in some cases.

Conflict of Interest

The authors declare that they have no conflict of interest.

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