Cater with Care

Impact of protein-enriched foods and drinks for elderly people

Janne Beelen

Thesis committee

Promotors
Prof. Dr C.P.G.M. de Groot
Personal chair at the Division of Human Nutrition
Wageningen University

Prof. Dr F.J. Kok
Emeritus Professor of Nutrition and Health
Wageningen University

Co-promotor
Dr N.M. de Roos
Assistant professor, Division of Human Nutrition
Wageningen University

Other members
Prof. Dr C. de Graaf, Wageningen University
Dr A.M. Beck, Herlev og Gentofte University Hospital, Herlev, Denmark
Dr M.A.E. de van der Schueren, HAN University of Applied Sciences, Nijmegen
Dr D.Z.B. van Asselt, Radboud University Medical Centre Nijmegen

This research was conducted under the auspices of the Graduate School VLAG (Advanced studies in Food Technology, Agrobiotechnology, Nutrition and Health Sciences).

Cater with Care

Impact of protein-enriched foods and drinks for elderly people

Janne Beelen

Thesis
submitted in fulfilment of the requirements for the degree of doctor
at Wageningen University
by the authority of the Rector Magnificus
Prof. Dr A.P.J. Mol,
in the presence of the
Thesis Committee appointed by the Academic Board
to be defended in public
on Friday 14 October 2016
at 1.30 p.m. in the Aula.

Janne Beelen

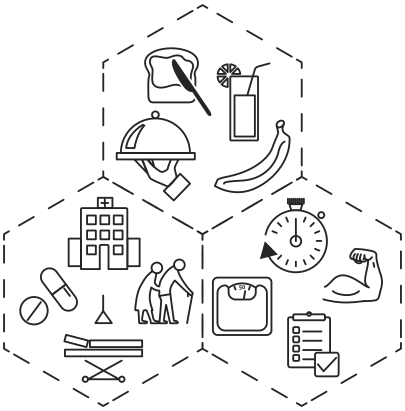
Cater with Care: Impact of protein-enriched foods and drinks for elderly people
142 pages

PhD thesis, Wageningen University, Wageningen, NL (2016)
With references, with summary in English

ISBN: 978-94-6257-881-4
DOI: 10.18174/387300

Table of contents

Chapter 1



General introduction

Current debate: research versus practice

No one questions whether undernutrition as seen in children in low- and middle-income countries should be treated. No food clearly means death in these circumstances. In contrast, the value of treating undernourished older adults with supplemental foods and drinks is under debate. In 2011, The Dutch Health Council stated that evidence to support nutritional supplementation of energy and protein for older adults who were classified as undernourished was inconclusive.[1] Arguments included that the available studies were of substandard quality and that none of the studies showed a causal relation between undernutrition and mortality risk. According to the Health Council, RCTs should be done to study the effects of nutritional supplementation with protein and energy on health outcomes, such as hospital stay, mortality, function, and quality of life. These RCTs would need to be conducted within homogenous groups of undernourished elderly people.

The Council's report was published during a time when undernutrition, especially in older adults, was high on the agenda of the Dutch government. Its conclusions were disappointing in the eyes of geriatricians and dietitians, who urged the need for nutritional guidelines on treating undernourished older patients.[2-4] Their biggest objection to the report was that the call for homogenous study populations of older patients is contradictory to the reality of clinical practice.[3] A positive result of the report, on the other hand, was that it stimulated research with well-designed trials.

This thesis describes studies among elderly with a high risk of losing muscle mass and function, due to hospitalization, inactivity, and a low protein intake. We investigated whether these older adults would benefit from nutritional treatment using a new strategy of enriched foods and drinks. We chose this strategy because the promising results with oral nutritional supplements (ONS) appeared to be hampered by their low compliance at the long-term. In addition to intake, physical performance outcomes were measured to add insights to the current debate on improving protein intake levels for older adults at risk of undernutrition.

Undernutrition in the elderly

Aging population

The number of older adults within our society is rapidly increasing. About 3 million people were aged 65 years and over in the Netherlands in 2015.[5] This number is estimated to increase to 4.7 million in 2060, accounting by then for 26% of the total population.[6] In accordance with Dutch government policy the vast majority of this older population will be living at home independently, for which the older adults require an optimal health status.[6] However, as people get older they often face multiple chronic diseases, or get acutely ill.[7] Both chronic and acute illness can lead to hospitalization or institutionalization.

Undernutrition or malnutrition

The terms 'undernutrition' and 'malnutrition' are often used interchangeably. The definition of malnutrition is: 'a state of nutrition in which a deficiency, excess or imbalance of energy, protein, and other nutrients causes measurable adverse effects on tissue/body form (shape, size, and composition) and function, and clinical outcome'.[8] This is a very broad definition which describes both over- and undernutrition, and considers both macronutrients and micronutrients. The term 'undernutrition', as used in this thesis, is primarily used to describe protein energy malnutrition [9] and is defined as: 'a disorder of nutritional status resulting from reduced nutrient intake or impaired metabolism'. Undernutrition is a common problem when suffering from a chronic or acute disease, hence it is also called disease-related undernutrition.[10]

For a variety of reasons, a large number of older adults are at risk of or are suffering from undernutrition, which may lead to an inadequate nutritional intake. This can have high-impact negative effects on their health.[11] Undernutrition is associated with several adverse clinical outcomes such as an impaired immune function, delayed wound healing, prolonged treatment duration, and increased morbidity and mortality.[10,12] Clinical conditions such as disease affect the nutritional status of patients, but this also works vice versa.[13]

A problem of undernutrition is that it is often invisible and hard to identify. Multiple screening tools have been developed to detect (the risk of) undernutrition. A commonly used screening tool in the clinical setting is the malnutrition universal screening tool ('MUST').[14] Additionally, the MUST score is used to monitor the prevalence of undernutrition in different health care settings. The Dutch National Prevalence Survey of Care Problems investigated the prevalence of undernutrition in hospitalized patients and found that 22% of them was undernourished and that 19% was at risk of malnutrition. The prevalence of undernutrition in long term care (e.g. nursing homes) was 17%, and approximately 28% was at risk of undernutrition.[15]

Such high prevalence of undernutrition also comes with a price: the total additional costs of managing undernourished patients in the Netherlands were estimated at €1.9 billion in 2011. A striking finding was that these costs are about four times higher for patients of 60 years and older than for younger adult patients.[16]

Sarcopenia

When older adults are undernourished and are physically inactive, they are prone to develop sarcopenia.[17,18] Sarcopenia is defined as the age-related loss of skeletal muscle mass and function, which increases the risk of falls, mobility disorders and difficulties in performing activities of daily living (ADL).[10,18,19] This decline in functionality subsequently reduces the independence and quality of life of older individuals.[20] Decline in muscle mass and function is also a consequence of bed rest during hospitalization. Older patients have a 3 to 6-fold greater rate of muscle loss during bed rest than younger adults have. As a consequence, older patients lose more muscle strength, power and functional capacity during hospitalization than younger adults do.[21]

Protein intake in the elderly

Total recommended protein intake per day

An adequate dietary protein intake plays an important role in the prevention and management of undernutrition and sarcopenia. The current recommended dietary allowance (RDA) for all adults is set at 0.8 g protein per kg bodyweight per day (g/kg/d). The RDA represents the estimated minimum intake level that meets the nutrient requirements of nearly all (97 to 98 percent) healthy individuals, which should not be confused with the optimal intake levels for physical functioning.[22]
The RDA for protein is based on nitrogen balance studies, which are usually done in healthy adults. Gaillard et al. [23], however, did a nitrogen balance study in hospitalized older adults and found that they needed a protein intake of 1.06 ± 0.28 g/kg/d to reach a neutral nitrogen balance. The Dutch Malnutrition Steering Group developed guidelines on the treatment of undernourished patients, including a recommended protein intake of 1.2 - 1.5 g/kg/d for patients at risk of undernutrition.[24] This is in line with guidelines of the European Society for Clinical Nutrition and Metabolism (ESPEN).[25] Taken these arguments into account, the international PROT-AGE study group recently recommended a daily protein intake of 1.2 - 1.5 g/kg/d for older individuals suffering and rehabilitating from acute or chronic diseases.[26]
Furthermore, it is believed that all older adults – not just the undernourished – need more protein than 0.8 g/kg/d to maintain muscle mass and function. This higher need is partly due to an age-related decline in anabolic response to the ingested protein.[22,26-28] Whether this higher protein intake optimally stimulates muscle functioning in older adults on the long term still needs to be determined, as well as its efficacy in a study population of hospitalized older adults who were affected by bed rest.

In this thesis, the overall research question was whether a protein intake of 1.2 - 1.5 g/kg/d during a longer period would result in improved recovery in such a study population after hospitalization.

Timing of protein intake: should we divide protein over the day?

Besides the total daily protein intake, an ongoing discussion exists on the timing of protein ingestion and its effect on preservation of muscle mass in older adults. Older adults have a reduced response to protein intake, leading to less muscle protein synthesis than seen in younger adults.[29,30] This reduced response is referred to as anabolic resistance.[31,32] To overcome this anabolic resistance, several strategies have been proposed. An often mentioned strategy is to ingest 25 - 30 gram protein per main meal, 3 times a day. This would stimulate muscle protein synthesis maximally and preserve skeletal muscle mass.[27,33]
An alternative strategy is 'protein pulse feeding': a high percentage of the total daily protein intake is consumed at once, for instance 70 - 80% of the total daily protein is consumed in one dose at noon.[34-36] This strategy was shown to be more effective than dividing protein over 4 meals in improving lean mass in older patients who were at risk of undernutrition.[35] Moreover, it resulted

in a more positive nitrogen balance in elderly women who ingested 80% of daily protein at once compared to the women who received the daily protein intake spread over 4 meals.[34]
Both strategies stimulate muscle protein synthesis, but which one is most effective needs further studies in several elderly populations. It has been suggested that pulse feeding would be more effective in a hospitalized group, due to their anabolic-resistant state [37], while for healthy older adults, there is a growing consensus that a protein intake of 25 - 30 g per main meal is most beneficial for muscle protein synthesis.[37] From a practical point of view, it can be argued that protein pulse feeding is neither feasible outside a clinical setting, nor doable for a longer term or with regular products. It is already challenging for older adults to consume 25 - 30 gram during the 3 main meals of the day.[38-40]
In the studies in this thesis, the aim was to increase total daily protein intake to a level of 1.2 - 1.5 g/kg/d, but also to reach the threshold of 25 - 30 gram protein per main meal. We did not further study pulse feeding strategies, because it did not fit the context of the studies.

Current protein intake of elderly

Several studies showed that the protein intake of hospitalized and recently discharged older adults averages 0.9 g/kg/d, which is well below the levels as recommended by the PROT-AGE group.[41,42] Protein intake of hospitalized older patients in general is lower [43,44] than that of community-dwelling [40] or institutionalized older adults.[38] Dutch older adults have a low protein intake in particular during breakfast; on average only 12 gram.[38]
In general, it is difficult for older adults to simply increase the amount of food they consume to obtain a sufficient protein intake. Many experience a loss of appetite due to physiological changes such as impaired senses of taste and smell and increased satiation signals. This situation is worsened when they are acutely or chronically ill and suffer from side effects of medication, poor dentition, functional disabilities or social isolation and depression.[7,11,45] When the recommended protein intake is not achieved through regular foods, ONS are often prescribed.[11] In practice their effect on intake may be limited by poor compliance due to a low palatability, and negative effects on satiety.[11,46] Other commonly used strategies to increase protein intake include meal fortification, stimulation of consuming between-meal snacks or eating more small meals during the day, and giving dietary advice. Despite these efforts, the majority of the older adults still do not reach their recommended protein intake.[11,47-49] Therefore, more effective strategies to increase protein intake of older adults are warranted, as will be discussed in the next paragraph.

New strategies to increase protein intake

To overcome older adults' difficulties in consuming enough protein, enriching foods and drinks that are part of their daily menu might be an effective strategy. Protein-enriched familiar foods and drinks could be a solution, especially when both preferences and physiological needs are taken into account. The Cater with Care® project developed a variety of protein-enriched familiar foods and drinks, such as bread, beverages and soups, tailored to the needs and preferences of older adults. If such protein-enriched foods and drinks are consumed in the same amount as regular food products, protein intake will automatically increase. However, protein-enriched food products are suggested to be more satiating than isocaloric carbohydrate-enriched food products.[50] This might limit the intake of these products. Another undesired effect could be that the higher protein intake from the enriched food products is compensated by choosing low protein foods and drinks during the rest of the day. Two recent studies, one in a hospital and the other one in a rehabilitation center, found promising results for protein-enriched bread and drinking yoghurt.[41,51] As a result of these protein-enriched products, protein intake of the hospitalized older patients increased to a level of 1.1 g/kg/d.[41] For the participants in the rehabilitation center the protein intake increased to a level of 1.6 g/kg/d.[51] However, the intervention in the hospital was only three days, and the intervention period in the rehabilitation center was limited to three weeks. Longer intervention periods may lead to boredom of these protein-enriched foods on a longer term and consequently lead to a decreasing protein intake. To our knowledge, no studies have used protein-enriched foods and drinks on a longer term among older adults who live independently at home, and the effects on protein intake on a longer term are therefore unknown.

Effects of protein supplementation on physical performance

Two major goals of medical treatment, besides curing illness, are preserving independence in activities of daily living (ADL) and quality of life.[52,53] Both are among the outcome measures that were recommended by The Health Council.[1] Until now, only a few studies have been published on the effects of dietary protein supplementation – mostly in the form of ONS – on ADL independence of older individuals.[49,54-56] Unfortunately, these studies have not been able to improve ADL independence. The lack of results on ADL may be due to the insensitivity of the tool used to measure ADL: the Barthel Index.[57] It has been suggested that the sensitivity of the Barthel Index is affected by "floor and ceiling effects" [58,59], and as a result changes in ADL may have gone undetected. Therefore, it may be worthwhile to study other functionality outcomes to gain a better understanding of the effects of protein supplementation. One of these interesting functionality outcomes could be physical performance. Physical performance of frail older adults has been shown to be positively affected by protein supplementation in the form of ONS.[60,61] At this point, it is not known if protein-enriched foods and drinks can improve physical performance and other functional outcomes such as muscle strength or independence in ADL. In this thesis, these outcomes were included in an RCT with a study population of older patients after hospitalization.

Rationale and outline of this thesis

Clearly, when it comes to tackling undernutrition in hospitals and other care settings there are still a number of knowledge gaps, along with a lack of evidence from well-designed intervention studies. In this thesis, these are addressed in a coherent way with the overall aim to evaluate the impact of protein-enriched foods and drinks on protein intake and performance outcomes among older adults.

The ultimate goal was to study the effectiveness in an RCT. However, before the effects of protein-enriched products could be studied, the products needed to be developed and tailored to fit the needs of the target group. Undernourished older adults and dietitians were interviewed to gain knowledge on the current dietetic treatment and perceived barriers for this treatment. Furthermore, consumer insights were gathered to learn about older adults' needs, wishes and current eating habits (**chapter 2**). Based on literature and the findings of the interviews we chose to focus on protein-enrichment of familiar foods and drinks, not on enrichment of micronutrients. An observational study was then conducted in hospital Gelderse Vallei to investigate the energy and protein intake of hospitalized older patients at low and high risk of undernutrition (**chapter 3**). In this study, we also investigated which foods and drinks were often consumed by these older patients to fit the Cater with Care assortment best to the eating habits of older adults.

When the first enriched products were available, we tested these in a pilot study among institutionalized older adults (**chapter 4**). The aim of this pilot study was to investigate whether protein-enriched familiar food products enabled institutionalized older adults to reach a protein intake of at least 1.2 g/kg/d. Furthermore, the results of this pilot study were used to improve the newly developed products.

When the assortment had enough variety in types of products and flavors to provide ample choice during the whole day, we conducted a randomized controlled trial in hospitalized patients during and after hospital discharge. **Chapter 5** describes the hospital phase of this study in which we investigated whether replacing regular foods and drinks by protein-enriched varieties would increase the protein intake of hospitalized older patients to the recommended intake level of 1.2-1.5 g/kg/d. **Chapter 6** describes the home phase of the study in which we followed older patients for 6 months after hospital discharge. By increasing the protein intake to a level of 1.2-1.5 g/kg/d during a 12-week intervention period, we aimed to improve physical performance.

In the final chapter of this thesis, **chapter 7**, the main findings of the studies are summarized and discussed. This general discussion puts the findings into perspective, and gives implications for practice and suggestions for future research.

References

1. Health Council of the Netherlands. Undernutrition in the elderly. The Hague, 2011.
2. Nederlands Tijdschrift voor Voeding & Diëtetiek. Mening: Ondervoeding onder de loep. 01-01-2012 2012. http://www.ntvd-site.nl/meningen/ondervoeding-onder-de-loep/ (accessed 31-05-2016 2016).
3. van Asselt DZB, Olde Rikkert MGM. Health Council of the Netherlands underestimates interactions in undernutrition in the elderly. Ned Tijdschr Geneeskd 2012; 156(3): A4446.
4. van Asselt DZB, van der Cammen TJM, Disselhorst LGM, et al. Assessment and treatment of malnutrition in Dutch geriatric practice: consensus through a modified Delphi study. Age Ageing 2012; 0: 1-6.
5. Centraal Bureau voor de Statistiek. Prognose intervallen van de bevolking; leeftijdsgroep, 2015-2060. 18-12-2014 2016. http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82682ned&D1=a&D2=0,21-23&D3=0&D4=0,5,10,15,20,25,30,35,40,l&VW=T (accessed 02-06-2016 2016).
6. Giesbers H. VA, Beer J. de,. Vergrijzing samengevat (Aging summarized). In: Volksgezondheid Toekomst Verkenning, Nationaal Kompas Volksgezondheid. . 2013. http://nationaalkompas.nl/bevolking/vergrijzing/vergrijzing-samengevat (accessed February 15, 2016.
7. Inzitari M, Doets E, Bartali B, et al. Nutrition in the age-related disablement process. J Nutr Health Aging 2011; 15(8): 599-604.
8. Stratton RJ, Green CJ, Elia M. Scientific criteria for defining malnutrition. 1ed. In: Stratton, RJ, Green, CJ, Elia, M, eds. Disease-related malnutrition: an evidence-based approach to treatment: CABI Publishing; 2003.
9. Lochs H, Allison SP, Meier R, et al. Introductory to the ESPEN Guidelines on Enteral Nutrition: Terminology, Definitions and General Topics. Clin Nutr 2006; 25(2): 180-6.
10. Norman K, Pichard C, Lochs H, Pirlich M. Prognostic impact of disease-related malnutrition. Clin Nutr 2008; 27(1): 5-15.
11. Nieuwenhuizen WF, Weenen H, Rigby P, Hetherington MM. Older adults and patients in need of nutritional support: review of current treatment options and factors influencing nutritional intake. Clin Nutr 2010; 29(2): 160-9.
12. Leistra E, Willeboordse F, Visser M, et al. Predictors for achieving protein and energy requirements in undernourished hospital patients. Clin Nutr 2011; 30(4): 484-9.
13. Sullivan DH, Sun S, Walls RC. Protein-energy undernutrition among elderly hospitalized patients: A prospective study. JAMA 1999; 281(21): 2013-9.
14. Stratton RJ, Hackston A, Longmore D, et al. Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. Br J Nutr 2004; 92(05): 799-808.
15. Halfens RJG MJ, Meesterberends E, van Nie NC, Neyens JCL, Rondas AALM, Schols JMGA,. Rapportage Resultaten: Landelijke Prevalentiemeting Zorgproblemen 2012 (Report of Results: National Prevalence Survey of Care Problems 2012). Maastricht: Maastricht University, 2012.
16. Freijer K, Tan SS, Koopmanschap MA, Meijers JMM, Halfens RJG, Nuijten MJC. The economic costs of disease related malnutrition. Clin Nutr 2013; 32(1): 136-41.
17. Morley JE. Undernutrition in older adults. Fam Pract 2012; 29: i89-i93.
18. Morley JE. Sarcopenia in the elderly. Fam Pract 2012; 29(suppl 1): i44-i8.
19. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. Sarcopenia: European consensus on definition and diagnosis: Report of the European Working Group on Sarcopenia in Older People. Age Ageing 2010; 39(4): 412-23.
20. Rizzoli R, Reginster J-Y, Arnal J-F, et al. Quality of Life in Sarcopenia and Frailty. Calcif Tissue Int 2013; 93(2): 101-20.
21. English KL, Paddon-Jones D. Protecting muscle mass and function in older adults during bed rest. Curr Opin Clin Nutr Metab Care 2010; 13(1): 34.
22. Wolfe RR, Miller SL. The recommended dietary allowance of protein: A misunderstood concept. JAMA 2008; 299(24): 2891-3.
23. Gaillard C, Alix E, Boirie Y, Berrut G, Ritz P. Are elderly hospitalized patients getting enough protein? J Am Geriatr Soc 2008; 56(6): 1045-9.
24. Dutch Malnutrition Steering Group. Guideline Screening and and treatment of malnutrition. Amsterdam, 2011.
25. Deutz NEP, Bauer JM, Barazzoni R, et al. Protein intake and exercise for optimal muscle function with aging: Recommendations from the ESPEN Expert Group. Clin Nutr 2014; 33(6): 929-36.

26. Bauer J, Biolo G, Cederholm T, et al. Evidence-Based Recommendations for Optimal Dietary Protein Intake in Older People: A Position Paper From the PROT-AGE Study Group. J Am Med Dir Assoc 2013; 14(8): 542-59.
27. Wolfe RR, Miller SL, Miller KB. Optimal protein intake in the elderly. Clin Nutr 2008; 27(5): 675-84.
28. Volpi E, Campbell WW, Dwyer JT, et al. Is the Optimal Level of Protein Intake for Older Adults Greater Than the Recommended Dietary Allowance? The Journals of Gerontology Series A: Biological Sciences and Medical Sciences 2013; 68(6): 677-81.
29. Katsanos CS, Kobayashi H, Sheffield-Moore M, Aarsland A, Wolfe RR. Aging is associated with diminished accretion of muscle proteins after the ingestion of a small bolus of essential amino acids. The American Journal of Clinical Nutrition 2005; 82(5): 1065-73.
30. Cuthbertson D, Smith K, Babraj J, et al. Anabolic signaling deficits underlie amino acid resistance of wasting, aging muscle. The FASEB Journal 2005; 19(3): 422-4.
31. Burd NA, Gorissen SH, van Loon LJ. Anabolic resistance of muscle protein synthesis with aging. Exerc Sport Sci Rev 2013; 41(3): 169-73.
32. Rennie MJ. Anabolic resistance: the effects of aging, sexual dimorphism, and immobilization on human muscle protein turnover. Applied Physiology, Nutrition, and Metabolism 2009; 34(3): 377-81.
33. Paddon-Jones D, Rasmussen BB. Dietary protein recommendations and the prevention of sarcopenia: Protein, amino acid metabolism and therapy. Curr Opin Clin Nutr Metab Care 2009; 12(1): 86-90.
34. Arnal M-A, Mosoni L, Boirie Y, et al. Protein pulse feeding improves protein retention in elderly women. The American Journal of Clinical Nutrition 1999; 69(6): 1202-8.
35. Bouillanne O, Curis E, Hamon-Vilcot B, et al. Impact of protein pulse feeding on lean mass in malnourished and at-risk hospitalized elderly patients: A randomized controlled trial. Clin Nutr 2013; 32(2): 186-92.
36. Arnal M-A, Mosoni L, Dardevet D, et al. Pulse Protein Feeding Pattern Restores Stimulation of Muscle Protein Synthesis during the Feeding Period in Old Rats. The Journal of Nutrition 2002; 132(5): 1002-8.
37. Paddon-Jones D, Campbell WW, Jacques PF, et al. Protein and healthy aging. The American Journal of Clinical Nutrition 2015; 101(6): 1339S-45S.
38. Tieland M, Borgonjen-Van den Berg KJ, van Loon LJC, de Groot LC. Dietary protein intake in community-dwelling, frail, and institutionalized elderly people: scope for improvement. Eur J Nutr 2012; 51(2): 173-9.
39. Tieland M, Borgonjen-Van Den Berg KJ, Van Loon LJC, de Groot LCPGM. Dietary protein intake in dutch elderly people: A focus on protein sources. Nutrients 2015; 7(12): 9697-706.
40. Ocké M.C. B-REJM, de Boer E.J., Wilson-van den Hooven C., Etemad-Ghameshlou Z., Drijvers J.J.M.M., van Rossum C.T.M., . Diet of community-dwelling older adults. Dutch National Food Consumption Survey-Older adults 2010-2012: National Institute for Public Health and the Environment, 2013.
41. Stelten S, Dekker IM, Ronday EM, et al. Protein-enriched 'regular products' and their effect on protein intake in acute hospitalized older adults; a randomized controlled trial. Clin Nutr; 34(3): 409-14.
42. Neelemaat F, Lips P, Bosmans JE, Thijs A, Seidell JC, van Bokhorst-de van der Schueren MAE. Short-term oral nutritional intervention with protein and & vitamin D decreases falls in malnourished older adults. J Am Geriatr Soc 2012; 60(4): 691-9.
43. Manning F, Harris K, Duncan R, et al. Additional feeding assistance improves the energy and protein intakes of hospitalised elderly patients. A health services evaluation. Appetite 2012; 59(2): 471-7.
44. van Bokhorst–de van der Schueren MAE, Roosemalen MM, Weijs PJM, Langius JAE. High Waste Contributes to Low Food Intake in Hospitalized Patients. Nutr Clin Pract 2012; 27(2): 274-80.
45. Morley JE. Decreased food intake with aging. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences 2001; 56(suppl 2): 81-8.
46. Milne AC PJ, Vivanti A, Avenell A. . Protein and energy supplementation in elderly people at risk from malnutrition. Cochrane Database of Systematic Reviews 2009; (2).
47. Munk T, Beck AM, Holst M, et al. Positive effect of protein-supplemented hospital food on protein intake in patients at nutritional risk: a randomised controlled trial. J Hum Nutr Diet 2014; 27(2): 122-32.
48. Munk T, Seidelin W, Rosenbom E, et al. A 24-h a la carte food service as support for patients at nutritional risk: a pilot study. J Hum Nutr Diet 2013; 26(3): 268-75.
49. Smoliner C, Norman K, Scheufele R, Hartig W, Pirlich M, Lochs H. Effects of food fortification on nutritional and functional status in frail elderly nursing home residents at risk of malnutrition. Nutrition 2008; 24(11-12): 1139-44.
50. Bertenshaw EJ, Lluch A, Yeomans MR. Satiating effects of protein but not carbohydrate consumed in a between-meal beverage context. Physiol Behav 2008; 93(3): 427-36.

51. van Til A, Naumann E, Cox-Claessens I, Kremer S, Boelsma E, de van der Schueren MA. Effects of the daily consumption of protein enriched bread and protein enriched drinking yoghurt on the total protein intake in older adults in a rehabilitation centre: A single blind randomised controlled trial. J Nutr Health Aging 2014; 19(5): 525-30.
52. Neelemaat F, Bosmans JE, Thijs A, Seidell JC, van Bokhorst-de van der Schueren MA. Oral nutritional support in malnourished elderly decreases functional limitations with no extra costs. Clinical nutrition 2012; 31(2): 183-90.
53. Rizzoli R, Reginster JY, Arnal JF, et al. Quality of life in sarcopenia and frailty. Calcified tissue international 2013; 93(2): 101-20.
54. McMurdo ME, Price RJ, Shields M, Potter J, Stott DJ. Should oral nutritional supplementation be given to undernourished older people upon hospital discharge? A controlled trial. Journal of the American Geriatrics Society 2009; 57(12): 2239-45.
55. Wouters-Wesseling W, Wouters AE, Kleijer CN, Bindels JG, de Groot CP, van Staveren WA. Study of the effect of a liquid nutrition supplement on the nutritional status of psycho-geriatric nursing home patients. European journal of clinical nutrition 2002; 56(3): 245-51.
56. Lee LC, Tsai AC, Wang JY. Need-based nutritional intervention is effective in improving handgrip strength and Barthel Index scores of older people living in a nursing home: A randomized controlled trial. International journal of nursing studies 2015.
57. Mahoney FI, Barthel, D.W. Functional evaluation: the Barthel Index. Md State Med J 1965; 14: 61-5.
58. de Morton NA, Keating JL, Davidson M. Rasch Analysis of the Barthel Index in the Assessment of Hospitalized Older Patients After Admission for an Acute Medical Condition. Arch Phys Med Rehabil 2008; 89(4): 641-7.
59. Quinn TJ, Langhorne P, Stott DJ. Barthel Index for Stroke Trials: Development, Properties, and Application. Stroke 2011; 42(4): 1146-51.
60. Tieland M, van de Rest O, Dirks ML, et al. Protein supplementation improves physical performance in frail elderly people: a randomized, double-blind, placebo-controlled trial. Journal of the American Medical Directors Association 2012; 13(8): 720-6.
61. Kim CO, Lee KR. Preventive effect of protein-energy supplementation on the functional decline of frail older adults with low socioeconomic status: a community-based randomized controlled study. The journals of gerontology Series A, Biological sciences and medical sciences 2013; 68(3): 309-16.

Chapter 2

Undernutrition: who cares? Perspectives of dietitians and elderly patients on undernutrition treatment

Janne Beelen, Emmelyne Vasse, Canan Ziylan, Nancy Janssen, Nicole M de Roos, Lisette CPGM de Groot

Submitted

Abstract

Background: Many older adults are at risk of undernutrition. Dietitians play a key role in the management and treatment of undernutrition, but older adults have difficulties to comply with dietetic advices. This qualitative study investigated which barriers older adults experience in adhering to dietetic advice when being treated for undernutrition. Current dietetic practices and patients' experiences were studied, and the potential of protein-enriched regular products in undernutrition treatment was investigated.

Methods: We interviewed 18 older adults who were under treatment for undernutrition, and 13 dietitians. Semi-structured interview guides were used, and all interviews were audiotaped and transcribed verbatim. The interviews were coded with qualitative analysis software NVivo9, followed by content analysis to formulate main themes.

Results: The interviews resulted in seven themes, which related to three main topics: barriers for treating undernutrition in older adults, current dietetic treatment, and new strategies to complement current treatment. Low awareness of undernutrition and a lack of knowledge regarding undernutrition, physical limitations, and loss of appetite were found to be major barriers among older adults to counteract undernutrition. Dietitians focus mostly on increasing energy and protein intake. They fit their advices to the needs and habits of the patient, and prefer using regular food products first to increase intake, before prescribing oral nutritional supplements. Dietitians see a use for enriched regular products if these would fit into the habits of older adults, have small portion sizes, are easy to open and prepare, have good palatability and a variety of taste and texture.

Conclusions: Undernutrition awareness is low among older adults and they seem to lack knowledge on how to combat undernutrition despite the efforts taken by dietitians. Enriched products could enable older adults to better adhere to undernutrition treatment advices, provided that these products meet the needs and eating habits of older adults. If protein-enriched food products can replace regular, low-protein variants, older adults do not need to consume more, but can adhere to their usual pattern while consuming more protein.

Background

Globally a large number of older adults are at risk of, or already suffering from undernutrition, with highest prevalence rates seen among institutionalized and hospitalized older adults.[1] Undernutrition may be caused by a number of factors such as acute or chronic disease, dental and swallowing problems, changes in sensory perception and appetite, loneliness, and difficulties with meal preparation and doing groceries.[2-4] Negative consequences of undernutrition such as loss of weight and lean body mass may improve with energy and protein supplementation, and with dietary advice with or without oral nutritional supplements (ONS).[5,6] However, when ONS is consumed for prolonged periods, the compliance usually declines [7-9], so other strategies are needed to stimulate adherence to dietary advice.

In the Netherlands, dietitians play a key role in the management and treatment of undernutrition. Although guidelines for undernutrition management in the elderly have been developed for the primary and secondary care setting [10,11], a recent qualitative study found a lack of knowledge and awareness about undernutrition among other care professionals, which hampers timely treatment.[4] Furthermore, according to these interviewed professionals, there is a lack of awareness about undernutrition and its consequences among older adults themselves. This means that they are unlikely to seek help when they are becoming undernourished.

To improve dietary treatment of undernourished older adults, we need to learn more about barriers that older adults experience before and during dietetic treatment. To our knowledge, there are no studies that qualitatively studied this by interviewing older adults themselves; most studies have focused on health care professionals. Furthermore, it would be interesting to gain more information on eating habits of these vulnerable older adults. The most recent Dutch National Food Consumption Survey included a group of community-dwelling older adults [12], but did not succeed to include the most vulnerable older adults who are at risk of undernutrition.

We conducted a qualitative study as part of the Cater with Care project. This project – a collaboration between food companies, health care, and research institutes – focused on improving undernutrition treatment through enriched foods and drinks, and services. To develop the product portfolio, first insights into the physiological needs of older adults at risk of undernutrition were gained by literature study. This resulted in prioritizing protein-enrichment. To verify our choices and to get a better understanding how these products would fit the current treatment of undernutrition, we interviewed older adults who were being treated for undernutrition, and dietitians who treat undernourished older adults.

We focused especially on the following research questions:

1. Which barriers do older adults experience in adhering to dietetic advice when being treated for undernutrition?

2. What are current dietetic advices and what is the opinion of the older adults about these advices?
3. What are the opinions on enriched foods and drinks as a new strategy to complement current undernutrition treatment, and what are prerequisites for such products?

Methods

We used a qualitative study design and conducted semi-structured individual interviews with two study populations: older adults being treated for undernutrition and dietitians. Content analysis [13] was applied by using the data to define codes and themes, which is further explained in the data analysis section.

Study populations and data collection

We developed two interview guides: one for the older adults and one for the dietitians. These interview guides were developed with different ideas in mind. The older adults were asked pragmatic questions, considering their eating habits, what they think undernutrition means and what older people should consume to eat optimally. The dietitians were asked practical questions, such as what they currently advice and why in their view older adults are not able to adhere to advice, but they also got hypothetical questions such as "what if enriched products would be available, what would the prerequisites for these products be?"
These semi-structured interview guides were not based on theoretical knowledge but were developed based on questions that arose during brainstorm meetings between nutrition scientists and dietitians, hence they were practice focused. Content of these interview guides are discussed below per study population. The interviews were done by four researchers, and were audiotaped and transcribed verbatim. Ethical approval was obtained from the Social Sciences Ethics Committee of Wageningen UR.
Study procedures and data collection differed between the two study populations and are explained separately hereafter.

Older adults

We included convenience samples of community-dwelling older adults receiving home care and hospitalized older adults, who were all being treated for undernutrition since recently. In total, 8 community-dwelling older adults and 10 hospitalized older adults were interviewed. The median age of the older adults was 78.5 years (range: 60 – 92 years), of these 7 were female and 11 were male, and 12 of them were living with a partner and 6 lived alone.
The community-dwelling older adults were recruited from several primary care dietitians in the surroundings of Wageningen. The older adults were first contacted via telephone and invited

to participate, after which a face-to-face interview was done at their home. Usually no one else was present, except for some cases when a partner or family member was present. The hospitalized older adults, who all were seen by a dietitian during hospitalization, were recruited during their hospital stay in hospital Gelderse Vallei, Ede. Interviews took place at the bedside of the participant, with no one else present except for some partners or family members when the participant requested so.

All participants gave their written informed consent and confirmed this on audiotape before the interview started. Interviews with the older adults had a duration between 30 to 45 minutes. From twelve older adults we had verbatim transcripts and from six older adults we only had short reports on the interviews because the recordings failed. During analyses of the interviews we started with the transcripts and used the short reports to check if these confirmed the findings from the verbatim transcripts.

The interview guide for the older adults consisted of open questions on their ideas about healthy and adequate nutrition for older adults, their own eating habits, their ideas about undernutrition, and their experiences with the dietitian's advice. If applicable, we asked them about their experiences with ONS. Table 2.1 shows the main questions in the interview guides.

Table 2.1: Global overview of main interview questions (follow-up questions are not shown)

Questions per study group
<u>Older adults</u>
When we talk about proper and sufficient nutrition for older adults, what comes to mind?
How would you describe your usual eating habits?
What does undernutrition among older adults mean according to you?
How do older adults become undernourished?
What do you recall about the advice the dietitian gave you?
What changes did you need to make according to the advice?
What were your experiences with adhering to the dietary advice?
What are your experiences with clinical nutrition?
<u>Dietitians</u>
Do older adults know they are undernourished?
Are there agreements or protocols with physicians for referral of undernourished patients?
What dietary advice do you give undernourished older adults?
Are there any practical issues to take into account when you give a certain advice?
Why do you think older adults are or are not able to comply with your advice?
How can user friendliness of foods be improved for older adults?
What are your experiences with prescribing older adults clinical nutrition, such as ONS?
If you would have the possibility of using enriched regular products, as an alternative for ONS, what is your opinion about that?

Dietitians

To collect data from different perspectives on the treatment of undernourished older adults, we included dietitians working in various settings. We used a purposive participant sample of 13 dietitians, from primary care (private practices), secondary care (hospitals), and nursing and care homes, in the Netherlands. All approached dietitians participated in the interviews.

Dietitians were first contacted via email and then interviewed preferably face-to-face at their working place, with no one else present, or by telephone if a face-to-face meeting was not possible. Dietitians gave verbal consent to study participation after which the interview started. Interviews with the dietitians had a duration between 45 and 90 minutes. The interview guide for dietitians consisted of open questions on their experiences in treating older adults at risk of undernutrition, their usual advices and how their patients follow these, and their opinion about ONS and alternatives such as enriched foods.

Data analysis

Analyses started after all interviews were completed and both groups were analyzed together for commonalities. All transcripts were separately read by two researchers (JB and CZ). A coding scheme was then made and all transcripts were coded with NVivo 9 (QSR international Pty Ltd, Doncaster, Victoria, Australia) by the two researchers (JB and CZ) separately. After this, they discussed the outcomes and reached consensus about the coding in case of inconsistencies. Then, three researchers (JB, CZ and EV) identified the main themes from the interviews through a face-to-face discussion. The main themes are reported and quotes that illustrate these themes were selected. Each quotation is identified by a respondent number for the dietitians, quotations of the older adults are identified with the age, gender and setting of the respondent (see Table 2.2 for a clarification of dietitian respondent identifiers).

Table 2.2: Dietitian-identifiers per care setting

	D1	**D2**	**D3**	**D4**	**D5**	**D6**	**D7**	**D8**	**D9**	**D10**	**D11**	**D12**	**D13**
Primary care		×		×	×								×
Hospital	×					×		×	×	×	×		
Nursing and care homes			×	×	×		×			×		×	

Results

Because we coded and analyzed the interviews after all interviews were done, we found that data saturation was already present after 10 dietitians and after 7 older adults, but all results were used in the data analysis. Seven main themes could be identified from the interviews, which could be grouped into 3 topics: barriers for treating undernutrition in older adults, current dietetic treatment, and new strategies to complement current treatment. The results are presented in this order.

Barriers for treating undernutrition in older adults

Three themes were identified that related to barriers in the treatment of undernutrition among older adults; these themes were put forward by both the dietitians and older adults themselves.

Theme 1: Physical limitations and loss of appetite among older adults.

Physical limitations and decreased appetite of older adults were mentioned as barriers to comply with dietary advice. Both the dietitians and the older adults reported a decreased appetite within older adults leading to a decreased intake:

> "*I used to eat when I was hungry, and that was okay. Nowadays I have no appetite and as a result everything is less tasty.*" [man, 92 years, home]

Some of the older adults mentioned that they eat because they know they have to, or because their partner or children want them to eat:

> "*I don't feel hungry, but I have to eat 5 slices of bread a day. That's just a law, or a law.. well, you just really need to eat, right?*" [man, 68 years, hospital]

> "*I know I have to eat, and maybe it's just in my head that I don't want to eat… but well...*" [woman, 73 years, hospital]

Physical limitations were also an important barrier for complying with nutritional advices. Dietitians mentioned that it is too exhausting for many older adults to do groceries and to cook a hot meal like they used to do. Switching to ready to eat meals that are delivered at home were mentioned as possible solutions. However, these meals are not always very well appreciated or the older adults use one meal for two days, which is not the intention:

> "*We always said that when people start with Meals on Wheels that they become undernourished within half a year.[…] older people do not order 7 meals a week, but only 3 or 4 meals a week, and eat 2 days from one portion.*" [D7]

Theme 2: Low awareness and knowledge among older adults on undernutrition.
Dietitians mentioned that their patients do not think of themselves as being undernourished. They have to educate older adults about undernutrition and its health consequences. Moreover, according to dietitians, older adults think eating less and losing weight is a normal consequence of ageing and their lower physical activity pattern:

2

> *"What I often hear is that they feel like they eat enough and they don't need that much, because they don't do that much anymore." [D6]*

Furthermore, the dietitians often hear that older adults find it convenient and not really a problem at their age that they lost some weight.
Many of the older adults did not refer to themselves when they spoke about undernutrition, even though they were under treatment by a dietitian because of their poor nutritional status. They did not associate themselves with undernutrition:

> Interviewer: "*When we mention 'undernutrition among older adults', what comes to mind?*"
> Respondent: "*No, nothing comes to mind.*" [man, 74 years, hospital]

Moreover, the interviewed older adults associated undernutrition with developing countries or World War II.
Only after they explain their patients that undernutrition can cause fatigue, muscle weakness or delayed wound healing, the older adults start relating it to their own situation. When the older adults were asked what they thought would be healthy or adequate nutrition for their age, they mentioned bread, which contains fibers, and sufficient fruit and vegetables.

Furthermore, they mentioned it is important to eat moderately; not too much sugar or fat and not too much in general:

> "*And then they tell me 'well, older people need to eat a bit more.' Well, that's not true!*" [woman, 87 years, hospital]

Theme 3: Late referral to a dietitian.
Another issue that the dietitians raised is that physicians refer their patients to them too late. Dietitians in primary care mentioned that nutritional screening is not done routinely by the

general practitioners (GPs) and they feel that they should be consulted much earlier to provide proper nutritional care:

> "*One GP refers more often to me than others. The other GP, if we look at primary care, does not refer patients. And often [when dietitians get consulted] I see that they are consulted too late and that the situation has been like this for a longer time.*" [D12]

Dietitians who work in a hospital did not mention late referral by a physician as being a barrier. Primary care and nursing home dietitians mentioned that not all physicians are aware that undernutrition is a health concern and they don't feel valued enough by all doctors:

> "*For example, when we get someone who is being transferred from another nursing home or hospital. This person lost 5 kilos in a short time, so he gets protein- and energy enriched snacks, but I wasn't asked for a consultation after admission. So you ask the hospital nurses 'how come?' [response of nurses]: 'well, the doctor said, just wait a bit and see what happens, but we also did not really agree.' So, will they also wait a bit with consulting a physical therapist and see if someone starts walking by themselves? Or maybe they will just swallow properly by themselves, or would they consult the speech therapist?*" [D7]

In summary, the interviews in both groups indicated that physical limitations and loss of appetite were found to be major barriers to comply with dietetic advices concerning undernutrition. Furthermore, older adults are often not aware that they are undernourished and they lack knowledge regarding undernutrition and its health consequences. Lastly, according to dietitians, physicians seem to be unaware of undernutrition among older adults, and consequently refer them too late to a dietitian.

Current dietetic treatment

The next two themes reflect on current dietetic treatment as provided by dietitians. The dietitians mentioned how they try to tailor their advices to the needs and habits of their patients and gave their opinion on the role of nutritional supplements in dietetic treatment.

Theme 4: Dietetic treatment and advices.

Dietitians said to focus mostly on protein and energy undernutrition, not on micronutrients when we asked about their advices. The dietitians said that they try to educate the patients about the consequences of undernutrition and the accompanying complaints. Furthermore, they explained that their advice is based on a patient's first interview: they listen carefully what foods their patients like and dislike, and which eating patterns they have. Their advice should fit into the needs and habits of the patient. A practical advice that most of the dietitians give is to eat more often than only during the three main meals. Dutch older adults are not used to eat in-between meals, they usually only drink coffee or tea during these moments. These moments are, therefore, suitable to consume more nutrient-dense products. However, patients need to be motivated and see for themselves that extra eating occasions can improve their condition, otherwise it costs too much effort, according to the dietitians:

> "*I always try to get 6 eating and drinking moments in a day. To make sure that the three main meals are not too small but also not too big, and that they use three in-between meals.*"
> Interviewer: "*And does this usually work?*"
> Respondent: "*Yes, but they have to be motivated. Because they don't enjoy eating and drinking so much anymore when they are sick. And now they have to think about food and drinks all day. If they notice that it helps, then they are willing to do it. But they have difficulties with it.*" [D4]

The older adults themselves reacted diversely to the questions about the advice of in-between snack moments. Some of them like that they can eat smaller meals divided throughout the day, because 3 big meals are difficult to finish completely due to rapid satiety. Others, however, mentioned that they find it hard to get used to eating that often during a day. Another commonly given advice is the use of full fat dairy products and double sandwich fillings.

Theme 5: Regular products versus oral nutritional supplements.
Dietitians mentioned that they prefer to increase intake with regular food products first because these are familiar to the older adults and better fit in their eating habits. If that does not work, ONS is advised but dietitians mentioned these have a stigmatizing image and the taste is not well appreciated. Dietitians often mentioned that they tell their patients to see ONS as a medicine:

> "*Sometimes I say to people 'Yes, that ONS drink is a small sip, and you maybe have to force yourself to drink it, but it is important that you take it and think of it as a medicine.'*" [D3]

Some of the dietitians mentioned that not everyone likes the taste of ONS but this is different for every patient. They told us that they think it also matters how doctors, nurses, and dietitians talk about ONS. Care givers should not present it as a negative thing, although they might not like it themselves.

> "*What I notice, is that the way you talk about it to the patient makes a big difference. ONS has a bit of a negative image: 'it is sweet and it is hard on the stomach for a long time.' If you sell it like that, then nobody wants to use it. But if you say: 'there is lots of protein in it,*

and it has a fresh tangy taste to it.' That's how you can sell it! So the way you talk about it, makes a big difference." [D3]

The older adults gave mixed reactions on the questions what their experiences were with ONS. Some of them liked it because it was easy, but they did not like the taste. Others found the taste acceptable.

In summary, the interviews showed that dietetic advices should fit into the needs and habits of the patient. Although it is not a habit of most older adults, eating more frequently was a commonly given advice. Older adults needed to be motivated to apply this in their pattern. The focus of dietetic advice was mostly on protein and energy, not on micronutrients. Dietitians prefer using regular food products first to increase intake, before prescribing ONS. Drawbacks of ONS were a stigmatizing image and low palatability. Some of the older adults mentioned that they did not like the taste of ONS, while others found it good enough.

New strategies to complement current treatment

The last two themes discuss a new strategy to complement current undernutrition treatment options, in the form of enriched foods and drinks.

Theme 6: Enriched regular products.

We asked the dietitians about their ideas on enriched regular products as an alternative to ONS. Dietitians see a potential use for enriched products, if they taste better than ONS. Several positive and negative points were mentioned, but no specific dosages of nutrients per portion. Dietitians would find it positive if enriched products would fit better in the eating habits of their older patients than ONS does. This may improve compliance on the long term. They think it may fill a gap between using regular products and ONS:

> "*As an option between regular nutrition and ONS, I would like it to have more protein and calories than regular nutrition. This would be more preferable than, for instance full fat dairy. If it is protein enriched! That would be a better option than immediately starting with ONS, or a more attractive option […] because it would be tastier and more normal [than ONS]. And it is not yet medical nutrition.*" [D9]

The idea that it would be less "medical" has an upside and a downside: on the one hand dietitians often use the association with a medicine as a means to show the importance of being compliant with using ONS, while on the other hand the dietitians said ONS can be stigmatizing and would not feel as eating real food.

"*An advantage is that enriched foods are like normal foods, or are actually normal. People will feel less that they are using a medical related drink. I think that for some people that will help, but for some others it helps when it feels like a medicine.*" [D5]

Theme 7: Prerequisites for usage of enriched products.

When developing enriched products for a specific consumer group, consumer insights are essential. We asked the older adults about their eating patterns and what features influence these. The older adults mentioned during our interviews that they have certain traditional eating habits:

2

"*Well, just very normal, I would say plain Dutch meals: potatoes, vegetables and meat, and with some variety in it, then I feel fine.*" [man, 91 years, home]

The older adults told us, furthermore, that they stick to their usual food choices, even during hospitalization they ordered from the meal service what they would eat at home.

Furthermore, both the older adults and dietitians mentioned that older people usually have less appetite and therefore the portion sizes should become smaller than regular but it should provide the same amount of protein. It was also mentioned that enriched products should replace foods and drinks that are regularly consumed, not as an extra consumption or added volume.

When we asked about the packaging of products and their user friendliness, we got mixed answers from the dietitians. Some gave particular examples of difficult to open packages, including the milk and yoghurt cartons with a cap on it. They said, however, that they do not think about these practical issues when giving their patients advice. Furthermore, one-portion packages were said to be useful because the product will not expire so quickly, but on the other hand these are usually more difficult to open than larger packages. The older adults gave very clear comments on packages: the font used on labels is usually too small to read or packages are difficult to open. They mentioned that their fine motor control has decreased. Most of them have found their ways to open things, using scissors and other tools:

"*We sometimes struggle with it, but we have tools for it.*" [man, 91 years, home]

When it comes to product characteristics, dietitians stressed that new enriched products should come in a variety in flavors, taste and textures. This was based on their experience with ONS: most ONS products are in liquid form and most have a sweet taste, while taste and texture preferences differ among older adults.

To summarize the opinions about this new strategy, dietitians stated that enriched products should fit the eating habits of older patients to improve long-term compliance: small portion sizes, easy to open and prepare, good palatability and a variety of taste and texture. ONS fits the eating habits for some, but not for all older adults. The medical image of ONS might convince some older adults to use it, while it evokes resistance in others.

Discussion

This qualitative study described several barriers that hamper dietetic treatment of older adults at risk of undernutrition. First of all, older adults were unaware that they were at risk of undernutrition, and there is a lack of knowledge among older adults but also among GPs who refer the older adults too late to a dietitian. Secondly, the older adults experience physical limitations and loss of appetite which limits their adherence to dietetic advice. Dietitians said to focus mainly on protein and energy intake and first advice to eat more frequently, and increase portions of regular foods, before prescribing ONS. Enriched products could enable older adults to better adhere to undernutrition treatment advices, provided that these products meet the needs and eating habits of older adults.

Unawareness reduces the effect of dietetic treatment, and this barrier has been found earlier.[4] It may be related to misperception of what is healthy or a sufficient diet at old age. Misperception about diet quality has been found to result in overestimating vegetable and fruit intake by older adults.[14] Unawareness of a poor diet can hamper responsiveness to health promotion messages [14] and therefore dietetic treatment may not be as effective as desired. Another concerning finding was that the older adults in our study did not mention protein as being important for their health. Considering that these interviewees all received advice to eat more protein-rich foods, it was worrying to find a lack of knowledge about the importance of protein.

Dietitians appear to be dragging a dead horse when it comes to treating undernourished older adults. This can be explained by the Stages of Change model. When placing the two groups (older adults and dietitians) into the Stages of Change model there seems to be a mismatch.[15] This model includes five stages of behavior change: pre-contemplation, contemplation, planning, action, and maintenance stage. Unaware older adults can be placed in the pre-contemplation stage, meaning that they are not thinking of changing behavior because they do not see any nutritional problems. Older adults who are aware of their risk at undernutrition, but did not change their behavior yet, can be placed in the contemplation stage which means that they think and talk about making a change but do not know how. The interviewed dietitians are definitely aware of the risk and consequences of undernutrition, and offer their patients action plans. However, older adults will not fully grasp these action plans because they are not in the planning or action stage yet. It may be more effective if dietitians first assess in which stage a patient is, and working through the stages until the patient is ready for the planning or action stage.

Nutrition education specifically targeted at older adults may increase undernutrition awareness.[4] By increased awareness, they may become more responsive to dietitians' messages. Furthermore, nutrition education for GPs may increase awareness among GPs and lead to earlier referral. GPs should use their credibility [16] to get the message of being undernourished across. This can help dietitians to get older adults into the contemplation stage and move into the planning and action stages.

Although nutrition education may help to create awareness this can be time consuming, while it is of great importance to increase dietary intake of undernourished older adults as soon as possible. In a hospital setting, short-term options, such as nudging or replacing regular food products with enriched food products and meals, have shown to effectively increase intake.[17-20]

A large part of this study focused on current dietetic treatment for undernutrition and alternatives to clinical nutrition. Dietitians prefer using regular foods to increase intake, before prescribing ONS. Furthermore, dietitians indicated that they primarily focus on protein and energy intake, not on micronutrient intake. Considering these findings it seems that protein-enriched food products may be a potent strategy to fill the gap between regular foods and ONS. Furthermore, older adults will not be inclined to drastically change their lifelong eating habits. Therefore treatment should be in line with these habits and fit into their usual pattern.[21,22] Prerequisites for enriched products included a good palatability, a variety of flavors and textures, and small portions, because loss of appetite was found to be a major barrier to comply with dietetic treatment. Furthermore, from literature we know that perceiving personal relevance is key in accepting enriched foods and drinks.[21,23]

The findings of this study should be interpreted in the light of some methodological considerations. The interviews gave a better understanding of the barriers that older adults perceive concerning dietetic treatment, but a qualitative study should not be used to draw hard conclusions, and therefore results should be interpreted as explorative. The fact that most interviewed older adults just started receiving dietetic treatment, may have resulted in a homogenous group of respondents. It would have been interesting to also have interviewed older adults who successfully adhered to dietetic advice and were no longer at risk of undernutrition to learn how they overcame certain barriers. Furthermore, we contacted dietitians of whom we knew that they treated many older patients and therefore this was a very undernutrition-conscious group of dietitians. This was, however, a deliberate choice because we wanted to learn from the experiences of dietitians who actually treat these older patients. To our knowledge, this is the first study that both interviewed dietitians and their elderly patients, which in our opinion is essential to gain a more complete picture. Future studies should focus on creating awareness among older adults, for instance by nutritional education interventions.

Conclusions and implications

Undernutrition awareness is low among older adults and they lack a feeling of urgency to combat undernutrition. Undernourished patients should be treated immediately, but at the same time dietitians need to create awareness among their patients and need to educate them on the risks, consequences and treatment of undernutrition. Enriched products could enable older adults to adhere to undernutrition treatment, provided that these products meet the needs and eating habits of older adults. If protein-enriched food products can replace regular, low-protein variants, older adults do not have to change their habits while consuming more protein.

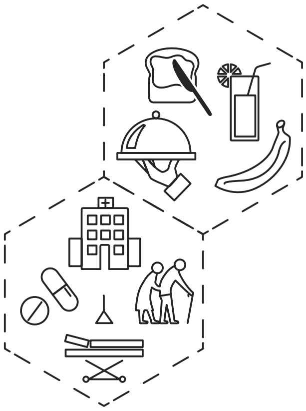
Acknowledgements

The authors would like to thank all the interviewees for their time and input.

References

1. Kaiser MJ, Bauer JM, Rämsch C, et al. Frequency of Malnutrition in Older Adults: A Multinational Perspective Using the Mini Nutritional Assessment. J Am Geriatr Soc 2010; 58(9): 1734-8.
2. Morley JE. Undernutrition in older adults. Fam Pract 2012; 29: i89-i93.
3. Soenen S, Chapman IM. Body weight, anorexia, and undernutrition in older people. J Am Med Dir Assoc 2013; 14(9): 642-8.
4. Ziylan C, Haveman-Nies A, van Dongen EJI, Kremer S, de Groot LCPGM. Dutch nutrition and care professionals' experiences with undernutrition awareness, monitoring, and treatment among community-dwelling older adults: a qualitative study. BMC Nutrition 2015; 1(1): 1-11.
5. Baldwin C, Weekes CE. Dietary advice with or without oral nutritional supplements for disease-related malnutrition in adults. The Cochrane Library 2011.
6. Milne AC PJ, Vivanti A, Avenell A. . Protein and energy supplementation in elderly people at risk from malnutrition. Cochrane Database of Systematic Reviews 2009; (2).
7. Bruce D, Laurance I, McGuiness M, Ridley M, Goldswain P. Nutritional supplements after hip fracture: poor compliance limits effectiveness. Clin Nutr 2003; 22(5): 497-500.
8. Lad H, Gott M, Gariballa S. Elderly patients compliance and elderly patients and health professional's, views, and attitudes towards prescribed sip-feed supplements. J Nutr Health Aging 2005; 9(5): 310-5.
9. Methven L, Rahelu K, Economou N, et al. The effect of consumption volume on profile and liking of oral nutritional supplements of varied sweetness: Sequential profiling and boredom tests. Food Qual Prefer 2010; 21(8): 948-55.
10. Dutch Association for Clinical Geriatrics (Nederlandse Vereniging voor Klinische Geriatrie). Richtlijn ondervoeding bij de geriatrische patiënt (Guideline undernutrition for the geriatic patient), 2013.
11. Dutch Malnutrition Steering Group. Guideline Screening and and treatment of malnutrition. Amsterdam, 2011.
12. Ocké M.C. B-REJM, de Boer E.J., Wilson-van den Hooven C., Etemad-Ghameshlou Z., Drijvers J.J.M.M., van Rossum C.T.M., . Diet of community-dwelling older adults. Dutch National Food Consumption Survey-Older adults 2010-2012: National Institute for Public Health and the Environment, 2013.
13. Kondracki NL, Wellman NS, Amundson DR. Content Analysis: Review of Methods and Their Applications in Nutrition Education. J Nutr Educ Behav 2002; 34(4): 224-30.
14. Dijkstra SC, Neter JE, Brouwer IA, Huisman M, Visser M. Misperception of self-reported adherence to the fruit, vegetable and fish guidelines in older Dutch adults. Appetite 2014; 82: 166-72.
15. Prochaska JO, Velicer WF. The Transtheoretical Model of Health Behavior Change. Am J Health Promot 1997; 12(1): 38-48.
16. van Dillen SM, Hiddink GJ, Koelen MA, de Graaf C, van Woerkum CM. Understanding nutrition communication between health professionals and consumers: development of a model for nutrition awareness based on qualitative consumer research. The American Journal of Clinical Nutrition 2003; 77(4): 1065S-72S.
17. van der Zanden L, van Essen H, van Kleef E, de Wijk R, van Trijp H. Using a verbal prompt to increase protein consumption in a hospital setting: a field study. International Journal of Behavioral Nutrition and Physical Activity 2015; 12(1): 110.
18. Lorefält B, Wissing U, Unosson M. Smaller but energy and protein-enriched meals improve energy and nutrient intakes in elderly patients. J Nutr Health Aging 2005; 9(4): 243-7.
19. Stelten S, Dekker IM, Ronday EM, et al. Protein-enriched 'regular products' and their effect on protein intake in acute hospitalized older adults; a randomized controlled trial. Clin Nutr; 34(3): 409-14.
20. Munk T, Beck AM, Holst M, et al. Positive effect of protein-supplemented hospital food on protein intake in patients at nutritional risk: a randomised controlled trial. J Hum Nutr Diet 2014; 27(2): 122-32.
21. van der Zanden LDT, van Kleef E, de Wijk RA, van Trijp HCM. Knowledge, perceptions and preferences of elderly regarding protein-enriched functional food. Appetite 2014; 80: 16-22.
22. Locher JL, Ritchie CS, Roth DL, Sen B, Vickers KS, Vailas LI. Food choice among homebound older adults: Motivations and perceived barriers. JNHA - The Journal of Nutrition, Health and Aging 2009; 13(8): 659-64.
23. van Kleef E, van Trijp HCM, Luning P. Functional foods: health claim-food product compatibility and the impact of health claim framing on consumer evaluation. Appetite 2005; 44(3): 299-308.

Chapter 3



A protein and energy enriched diet should not be restricted to only malnourished hospitalized elderly people

Janne Beelen*, Emmelyne Vasse*, Nicole M de Roos, Nancy Janssen, Lisette CPGM de Groot
*These authors contributed equally to the contents of the manuscript

Submitted

Abstract

Background & Aims: Protein and energy intakes of hospitalized elderly patients are lower compared to those of community-dwelling or institutionalized elderly. To improve the intake of hospitalized elderly, insight in their food choices and protein and energy intake is needed. The aim of this study was to investigate if 2 groups of hospitalized elderly patients, those at low and those at high risk of malnutrition, meet the recommended protein intake of 1.2 g/kg/d and their estimated energy requirement.

Methods: This cross-sectional study involved 80 patients of ≥65 years: 40 with a low risk and 40 with a medium/high risk of malnutrition. The latter group received a protein and energy enriched diet. In 62 patients a 24h-recall could be completed to estimate protein and energy intake. Energy requirements were estimated with the Harris-Benedict formula and multiplied by a disease factor of 1.3.

Results: From the 62 elderly hospitalized patients, 73% did not reach the recommended protein intake of 1.2 g/kg/d. The medium/high risk group had a higher protein intake than the low risk group (1.19 vs 0.89 g/kg/d; $p=0.003$). Overall, 34% of the 62 patients reached their energy requirement. Mean energy intake was higher but not significantly in the medium/high risk group (1724 vs 1575 kcal; $p=0.227$).

Conclusions: In our study, patients who received an energy and protein enriched diet because of their risk of malnutrition were better able to reach the protein and energy recommendations than patients with low risk of malnutrition at admission who received a standard diet. To prevent deterioration of nutritional status, we propose that all hospitalized elderly should therefore receive an energy and protein enriched diet during hospital stay.

Introduction

Since many years, malnutrition has been recognized as a common concern among hospital patients worldwide.[1] Screening in Dutch hospitals shows that approximately one in five hospitalized adults is malnourished.[2] An adequate protein intake plays an essential role in the prevention and management of malnutrition.[3,4]

In particular elderly patients are at risk of malnutrition. Recently, the ESPEN expert group formulated a recommendation for older people who are malnourished or at risk of malnutrition due to acute or chronic illness: their diet should provide 1.2-1.5 gram protein per kg body weight per day (g/kg/d) with even higher targets for individuals with severe illness or injury.[5] This recommendation is in accordance with the performance indicator on treatment of malnutrition of the Dutch Health Care Inspectorate (DHCI). This urges hospitals to screen all adult patients for malnutrition within 24 hours of admission, and to increase protein intake to at least 1.2g/kg/d on the fourth day of hospitalization in patients who are at high risk of malnutrition.[6,7] According to the PROT-AGE study group this target should also apply to elderly patients suffering from acute or chronic diseases without (the risk of) malnutrition.[8] For healthy older people both the Espen expert group and the PROT-AGE study group recommend a protein intake of at least 1.0–1.2g/kg/d to maintain function and lean body mass.[5,8]

3

The focus of most dietary interventions both in research [9-14] and in practice is on hospitalized elderly patients who are malnourished or at high risk of malnutrition, but this does not automatically infer that hospitalized elderly patients with a low risk of malnutrition reach recommendations. Studies show that the protein intake of hospitalized elderly patients in general is lower [11,15] than that of community-dwelling [16] or institutionalized elderly.[17]

The aim of this study was to investigate if hospitalized elderly patients at low and high risk of malnutrition meet the recommended protein intake of at least 1.2g/kg/d and their energy requirements. We also investigated which food groups provided most protein and energy.

Materials and Methods

Study design and subjects

This cross-sectional study was carried out from April to August 2013 in hospital Gelderse Vallei in Ede, the Netherlands. The hospital's research board approved the study protocol.

Patients of ≥65 years admitted to the departments of geriatrics, lung disease, neurology, internal medicine, orthopedics, vascular surgery or trauma were screened for inclusion into the study. These departments had the highest percentage of elderly patients or patients at risk of malnutrition in this hospital. Eligible patients were asked to participate in the study within the first two days after hospital admission and signed a written informed consent. Patients were not

eligible if their hospital stay was expected to be shorter than four days, or if they were terminally ill, cognitive impaired, diagnosed with delirium, received tube feeding or parenteral nutrition, were at risk of developing refeeding syndrome, had an estimated glomerular filtration rate eGFR $\leq$30 mL/min/1.73m^2, had a food allergy or intolerance that prevented them from ordering foods from the standard hospital menu, or had communication difficulties because of aphasia or not understanding Dutch.
We wanted to estimate the mean intake per group with a specified precision, and based our sample size calculation on the desired width of the 95% confidence interval (CI) for protein intake in both groups. Using a SD of 30g of protein [13] and a desired CI width of ±10g around the estimated intake, we calculated that we needed 36 patients per group, using the formula ½ CI width ≈ 2SE and SE=SD/√n. We aimed to include 40 patients per group to compensate for drop-outs.
The risk of malnutrition was based on the score on the Malnutrition Universal Screening Tool (MUST) (www.bapen.org.uk). We will refer to these groups as the low risk group (MUST-score=0) and the medium/high risk group (MUST-score≥1). All patients were screened for risk of malnutrition by a nurse with the MUST within 24 hours after hospital admission. The MUST consists of three items; BMI, weight loss and acute disease effect, which all score between 0 and 2 to a total MUST-score of 0 to 6.[18] Patients with different MUST scores receive different dietary treatments in the hospital. A MUST-score of 0 indicates a low risk of malnutrition and these patients receive a standard hospital menu. If the MUST-score ≥1, patients receive an energy and protein enriched diet consisting of protein enriched dairy products and protein-rich snacks in addition to the standard hospital menu. Patients with a MUST-score ≥2 are visited by a dietitian for dietary advice. The dietitian can prescribe oral nutritional supplements (ONS) if necessary.

Hospital meal service system

The meal service system in this hospital differs from those in other hospitals in the Netherlands. This hospital uses the At Your Request® meal service system (AYR) which allows patients to order foods and drinks from an extensive menu card between 7am and 7pm.[19] Patients can order food by calling the in-hospital nutrition call center, whose trained operators have access to their previous orders and type of diet, and see to it that food choices meet individual dietary requirements. All ordered foods, drinks and snacks are entered into the Menu Management System (MMS) and are stored in a database. The MMS includes the nutritional values of all available foods, drinks, and snacks per serving size. In case of composite foods, the nutritional value is calculated according to the nutritional value of each separate ingredient. Foods and drinks consumed outside AYR, such as foods and drinks brought by family, are not included in the ordering data.
Patients who receive an energy and protein enriched diet get an additional menu card from which they can order protein-rich foods, drinks, and snacks. Although they are stimulated to eat energy and protein-rich products by AYR call center operators, they are free to order other products.

Patients who are prescribed ONS by a dietitian need to order these through AYR.

Study outcomes and parameters

Characteristics

We collected data on gender, age, MUST-score at hospital admission, weight, height, length of hospital stay, number of visits by a dietitian, and prescription of ONS (yes or no) from the hospital electronic patient file. Weight, assessed by a nurse at hospital admission, and height, reported by the patient, were retrieved from the electronic MUST form.

Dietary intake and requirements

To determine if patients met their requirements for energy and protein intake a 24h-recall was completed between the 3rd and 7th day of hospital stay. Portion sizes were based on the MMS database and entered in grams into the web-based program Compl-eat (Department of Human Nutrition, Wageningen University, http://www.compleat.nl). Compl-eat was used to assign all food items to food groups according to the Dutch food composition table 2013 and to calculate total energy intake in kilocalories and total grams of protein intake per patient. These data were imported in SPSS for further analyses.

For each patient, protein intake per g/kg/d was calculated by dividing protein intake in grams by actual bodyweight. For patients with a BMI >27kg/m^2 we calculated protein intake in g per adjusted kg per day. Adjustment was done by calculating the body weight that corresponded with a BMI of 27kg/m^2 and the patient's height, as advised by the Dutch guideline for treatment of malnutrition.[20] Recommendations for protein intake were met if protein intake was at least 1.2g/adjusted kg/d.[5,8]

The energy requirement per patient was calculated with the Harris-Benedict formula [21] to estimate resting energy expenditure and this was multiplied by a factor of 1.3 to estimate 24h energy requirements.[20]

The contribution of different food groups to protein and energy intake was retrieved from MMS, using the ordering data of each participant on day 4 of hospital stay. We chose day 4 because this is in accordance with the performance indicator on treatment of malnutrition of the Dutch Health Care Inspectorate.[6,7] A top 5 of food groups that contributed most to protein and energy intake was calculated per study group. Furthermore, we calculated which single food products were ordered most often to gain insights in eating habits.

Data analysis

We used IBM SPSS statistics v19 for the statistical analysis. Descriptive statistics were performed for the baseline characteristics of the total study group and both malnutrition risk subgroups. All continuous variables had a normal distribution and are presented as mean ± standard deviation. Independent samples t-tests were performed to test for differences between the two groups. A p-value of <0.05 was considered statistically significant.

Results

Characteristics of participants

Eighty patients signed informed consent, 40 in each subgroup. From 62 of these 80 patients 24h-recalls and ordering data could be analyzed. Data of 18 patients could not be used for analysis due to various reasons, including early discharge and second thoughts about taking part in the study. Both groups consisted of 31 patients (Table 3.1). Characteristics from the patients for whom no intake or ordering data could be gathered, were not different from the initial 80 patients in terms of gender, age, body weight and BMI.

Table 3.1: Characteristics of study groups (shown as mean ± SD, unless specified otherwise)

	Low risk n = 31	Medium/high risk n = 31
Gender (M/F), n	16/15	16/15
Age (years)	77.4 ± 5.6	78.7 ± 6.4
BW (kg)[a]	80.5 ± 13.7	67.4 ± 18.6
Adjusted BW (kg)[a]	74.9 ± 9.3	64.4 ± 13.9
BMI (kg/m^2)[a]	27.7 ± 4.0	23.3 ± 5.8
BMI > 27 kg/m^2, n	16	7
Protein needs (g)	90 ± 11	77 ± 17
Energy needs (kcal)	1939 ± 259	1749 ± 341
Length of stay (days), median [min - max]	7.0 [5 - 39]	8.5 [4 - 25][b]
Department, n		
Internal medicine	5	6
Geriatrics	4	4
Lung disease	3	13
Trauma/Vascular surgery	4	5
Orthopedics	13	3
Neurology	2	0

[a] Statistical significant between group difference, $p<0.05$

[b] One patient died during hospital stay and is not included in this analysis

When comparing the 62 patients in the 2 study groups, we found that BMI and bodyweight were significantly higher in the low risk group and more patients in this group had a BMI >27.0 kg/m^2. Distribution over hospital departments differed between the two groups. In the low risk group patients were predominantly admitted to the orthopedics department whereas in the medium/high risk group this was the department of lung disease.

The 24h-recall was completed on the 4th or 5th day of hospital stay for most of the 62 patients, but due to practical issues four patients had their 24h-recall at day 3, 6, or 7. Food ordering data for day 4 could be gathered for 31 patients in the low risk group and 27 patients in the medium/high risk group. Other patients were discharged to home earlier than expected.

The MUST-scores of the 31 patients in the medium/high risk group varied between 1 and 6. Eighteen patients had a MUST-score ≥2. During the first four days of hospital stay, 22 patients in the medium/high risk group and one patient in the low risk group were visited by a dietitian. Seven patients in the medium/high risk group were prescribed ONS.

Dietary intake and requirements

Protein and energy intake based on the 24h-recall can be found in Table 3.2. Four patients in the medium/high risk group consumed one serving of ONS and one patient consumed two servings of ONS on the day of the 24h-recall, while none of the patients in the low risk group consumed ONS.

Protein intake

Protein intake as g per kg actual bodyweight was only slightly lower than per kg adjusted bodyweight (Table 3.2). Therefore, we describe the results for adjusted bodyweight only. The medium/high risk group had a significantly higher protein intake per kg adjusted bodyweight than the low risk group (p=0.003). In the medium/high risk group 12 patients had a protein intake of at least 1.2g/kg (Table 3.2), while this recommendation was met by only 5 patients in the low risk group.

Table 3.2: Protein and energy intake based on a 24h-recall (data are shown as mean ± SD (range), unless specified otherwise). Medium/high risk group receives an energy and protein enriched diet.

	Low risk group n = 31	**Medium/high risk group** n = 31
Protein intake (g/kg adjusted BW/day)	0.89 ± 0.31 [a] (0.15 – 1.42)	1.19 ± 0.45 (0.42 – 2.17)
Protein intake (g/kg actual BW/day)	0.83 ± 0.31 [a] (0.12 – 1.42)	1.16 ± 0.46 (0.42 – 2.17)
Protein (g/day)	64.9 ± 20.3	74.1 ± 25.0
Energy (kcal/day)	1575 ± 457	1724 ± 503
Protein level (g/kg) reached		
< 0,8 (n)	11	4
> 1,2 (n)	5	12

[a] Statistically significant difference between groups (p <0.05), tested with Independent T-test

Total protein intake in grams and distribution of protein intake over the day (Figure 3.1) was not significantly different between groups. The trend of a higher protein intake in the medium/high risk group, however, was seen at all meal moments. Dinner provided most protein in both groups.

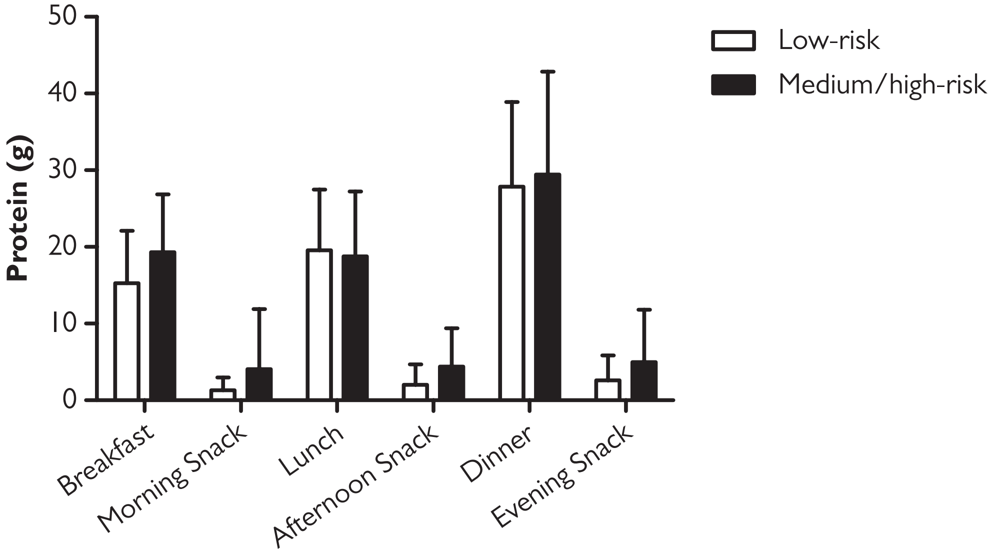


Figure 3.1: Protein per meal based on 24h recall (n=31 in both groups)

Energy intake

In the low risk group, 24 patients had an energy intake below 100% of their calculated energy requirements, compared to 17 patients in the medium/high risk group (Figure 3.2).

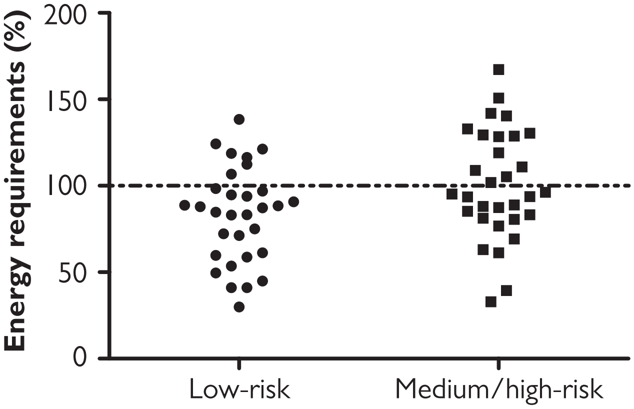


Figure 3.2: Individual energy intake based on 24h recall in percentage of energy requirements (n=31 in both groups)

Mean energy intake was about 150 kcal higher in the medium/high risk group than in the low risk group (p=0.227). In both groups, dinner contained the most energy of all meals; 579 kcal in the low risk group and 618 kcal medium/high risk group (Figure 3.3).

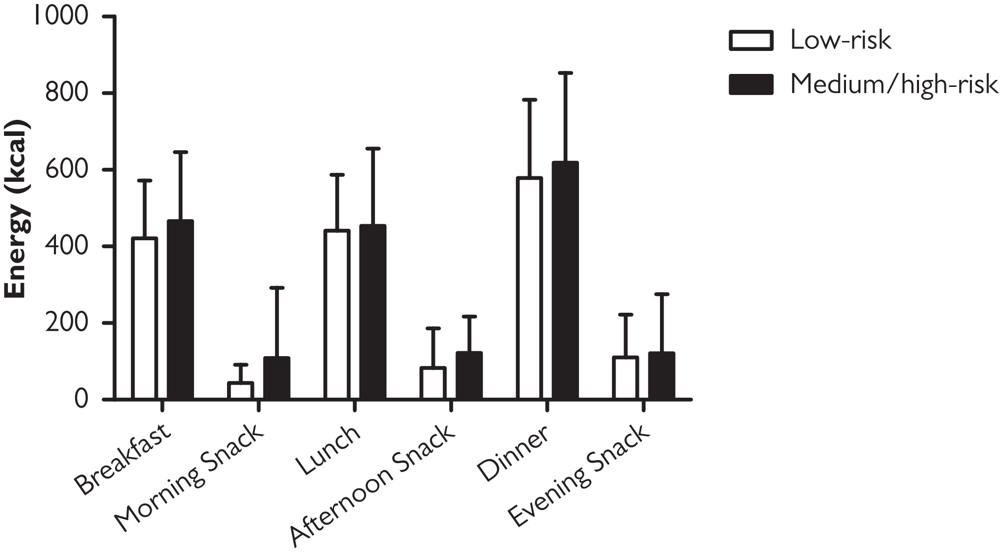


Figure 3.3: Energy per meal based on 24h recall (n=31 in both groups)

3

Protein and energy contribution of food groups

Ordering data for day 4 of hospital stay could be described for 58 patients. Dairy was the most important source of protein in both groups; dairy and bread for energy (Table 3.3). Other food groups that contributed to protein provision were bread and cheese, whereas the food group fats, oils and sauces also provided over 10% of energy in both groups.

Table 3.3. Contribution of food groups to total daily protein and energy in foods ordered on day 4 per risk group (in % and grams/kcal, on group level).

Low risk group		Medium/high risk group	
Protein	**% (g)**		**% (g)**
Dairy	19.4 (361)	Dairy	25.3 (478)
Bread	17.4 (325)	Cheese	14.6 (276)
Cheese	16.1 (300)	Bread	12.1 (228)
Meat and poultry	15.7 (292)	Composite foods	10.5 (199)
Fish	10.3 (192)	Meat and poultry	9.4 (177)
Other	21.1 (393)	Other	28.1 (531)
Energy	**% (kcal)**		**% (kcal)**
Bread	22.0 (9667)	Dairy	22.3 (9669)
Dairy	16.0 (7053)	Bread	14.7 (6362)
Fats, oils, sauces	14.7 (6451)	Fats, oils, sauces	11.2 (4858)
Cheese	7.1 (3109)	Composite foods	7.5 (3265)
Fruit	6.5 (2862)	Cheese	7.5 (3261)
Other	33.7 (14826)	Other	36.8 (15976)

The most frequently ordered food on day 4 was a slice of wheat bread, followed by low-fat margarine spread, tea, butter and Gouda cheese. There were no notable differences between the two risk groups in most frequently ordered foods.

Discussion

In this observational study we found that 73% of the elderly hospitalized patients did not reach the recommended protein intake of 1.2 g/kg/day. Patients who received an energy and protein enriched diet because of their risk of malnutrition were better able to reach the protein and energy recommendations than patients with low risk who received the standard hospital diet.

Food choice was one of the reasons for this difference: dairy products and cheese were more important protein sources in the medium/high risk group than in the low risk group. This can be explained by the fact that the energy and protein enriched diet includes enriched dairy products. Our study is unique in comparing protein intake between elderly patients who are at medium/high risk of malnutrition and therefore receive an energy and protein enriched diet, and elderly patients who are at low risk of malnutrition and therefore receive a standard hospital diet. For patients at medium/high risk of malnutrition, there is an international agreement on a recommended protein intake of 1.2g/kg/d.[5,8] Protein recommendations for elderly patients with a low risk of malnutrition are less clear. In our study, we set the recommendation for protein intake at 1.2g/kg/d, which is in agreement with the recommendation of the PROT-AGE study group for all elderly patients who are ill, regardless of their risk of malnutrition.[8] Gaillard et al. 2008 determined protein requirements of elderly hospitalized patients, by evaluating their nitrogen balance. Their study population included patients with various conditions not necessarily at risk of malnutrition. They found that these patients needed a protein intake of 1.06g/kg/d to reach a neutral nitrogen balance.[22] In our study a large proportion of the patients who were at low risk of malnutrition underwent orthopedic surgery. For these patients, a protein intake above the RDA of 0.8g/kg/d is recommended as it helps wound healing and the rehabilitation process.[23,24] Both the ESPEN expert group and the PROT-AGE study group recommend a protein intake of 1.0-1.2g/kg/d for healthy elderly persons to maintain function and lean body mass.[5,8] A protein intake of at least 1.2g/kg/d seems prudent for all hospitalized elderly patients, regardless of risk of malnutrition, because of increased protein needs during illness.

We are not the first to show that a protein recommendation of 1.2g/kg/d is difficult to achieve in hospital patients. An insufficient protein intake between 0.34 and 0.99g/kg in elderly hospitalized patients was reported earlier.[22,25,26] In our study most patients had difficulties meeting their recommended protein intake, in particular patients receiving the standard hospital diet. Moreover, patients in this group had a higher average bodyweight and therefore their protein needs were also higher. Offering an energy and protein enriched diet to all elderly patients would be a first important step in improving their protein intake during hospital stay.

A limitation of this study is that we did not follow-up on the patients after hospital stay and we do not know what the consequences are of a protein intake below needs during the short period of hospitalization. The hospitalization period is nowadays as short as possible and recovery mainly takes place at home. Median hospital stay in our study, however, was 7 days for the group at low risk and 8.5 days for the group at medium/high risk of malnutrition. This may be long enough to lose lean body mass if protein intake is insufficient.[27] More research is needed to estimate the protein and energy intake of elderly patients during and after hospital stay and to what extent it influences their lean body mass and recovery.

A strength of this study was the opportunity to study the food choices that elderly patients make during hospitalization through the AYR meal system. This well-rated system enables patients to have free choice in what to eat at any time they want.[19] This makes it more comparable to the situation at home.

Looking at protein sources, we found that dairy provided most protein and energy. Other food groups that contributed to protein in ordered foods were bread, meat, and cheese. This is more or less similar to a recent published paper that studied the protein intake of community-dwelling, frail and institutionalized elderly people.[28] These results suggest that elderly people do not change their eating habits during hospitalization. This knowledge can be used to improve the protein intake of elderly hospital patients. For instance, by fortifying the foods that are chosen most often by these patients with protein.

We based our intake findings on a 24h-recall whereas sources of energy and protein were based on the ordering data on day 4. We checked whether these data were similar, and found that the ordering data are a good proxy for intake on a group level, without relying on patients' recall abilities or nurse' registration.

3

To our knowledge, this is the first study on dietary intake of hospitalized elderly in which elderly patients were categorized based on their risk of malnutrition and type of diet. In our opinion, it is a point of concern that in the group of hospitalized elderly with a low risk of malnutrition less patients reached recommendations for protein and energy intake than in the group of hospitalized elderly who were at risk of malnutrition. A prudent solution could be to provide a protein and energy enriched diet to all elderly patients during hospital stay to better enable them to reach their protein and energy requirements.

Acknowledgements

The authors thank the participants, Wendy de Meij for her assistance with MMS, and Renske Geers for her assistance with Compl-eat.

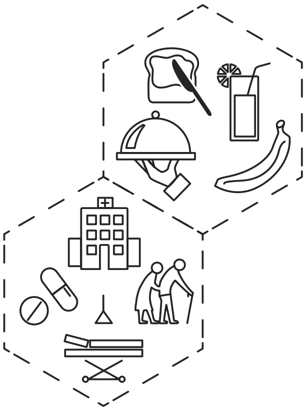
References

1. Stratton RJ, Green CJ, Elia M. Scientific criteria for defining malnutrition. 1ed. In: Stratton, RJ, Green, CJ, Elia, M, eds. Disease-related malnutrition: an evidence-based approach to treatment: CABI Publishing; 2003.
2. Halfens RJG MJ, Meesterberends E, van Nie NC, Neyens JCL, Rondas AALM, Schols JMGA,. Rapportage Resultaten: Landelijke Prevalentiemeting Zorgproblemen 2012 (Report of Results: National Prevalence Survey of Care Problems 2012). Maastricht: Maastricht University, 2012.
3. Milne AC PJ, Vivanti A, Avenell A. . Protein and energy supplementation in elderly people at risk from malnutrition. Cochrane Database of Systematic Reviews 2009; (2).
4. Baldwin C, Weekes CE. Dietary advice with or without oral nutritional supplements for disease- related malnutrition in adults. The Cochrane Library 2011.
5. Deutz NEP, Bauer JM, Barazzoni R, et al. Protein intake and exercise for optimal muscle function with aging: Recommendations from the ESPEN Expert Group. Clin Nutr 2014; 33(6): 929-36.
6. Dutch Health Care Inspectorate. 'Het resultaat telt 2012' (The result counts). Utrecht, 2014.
7. Dutch Health Care Inspectorate. 'Het resultaat telt 2013' (The result counts). Utrecht, 2015.
8. Bauer J, Biolo G, Cederholm T, et al. Evidence-Based Recommendations for Optimal Dietary Protein Intake in Older People: A Position Paper From the PROT-AGE Study Group. J Am Med Dir Assoc 2013; 14(8): 542-59.
9. Stelten S, Dekker I, Ronday E, et al. Protein-enriched 'regular products' and their effect on protein intake in acute hospitalized older adults; a randomized controlled trial. Clin Nutr 2014.
10. Bouillanne O, Curis E, Hamon-Vilcot B, et al. Impact of protein pulse feeding on lean mass in malnourished and at-risk hospitalized elderly patients: A randomized controlled trial. Clin Nutr 2013; 32(2): 186-92.
11. Manning F, Harris K, Duncan R, et al. Additional feeding assistance improves the energy and protein intakes of hospitalised elderly patients. A health services evaluation. Appetite 2012; 59(2): 471-7.
12. Jukkola K, MacLennan P. Nutritional supplementation in the elderly improving the efficacy of nutritional supplementation in the hospitalised elderly. Australas J Ageing 2005; 24(2): 119-24.
13. Neelemaat F, Lips P, Bosmans JE, Thijs A, Seidell JC, van Bokhorst-de van der Schueren MAE. Short-term oral nutritional intervention with protein and & vitamin D decreases falls in malnourished older adults. J Am Geriatr Soc 2012; 60(4): 691-9.
14. Leistra E, Willeboordse F, Visser M, et al. Predictors for achieving protein and energy requirements in undernourished hospital patients. Clin Nutr 2011; 30(4): 484-9.
15. van Bokhorst–de van der Schueren MAE, Roosemalen MM, Weijs PJM, Langius JAE. High Waste Contributes to Low Food Intake in Hospitalized Patients. Nutr Clin Pract 2012; 27(2): 274-80.
16. Ocké M.C. B-REJM, de Boer E.J., Wilson-van den Hooven C., Etemad-Ghameshlou Z., Drijvers J.J.M.M., van Rossum C.T.M., . Diet of community-dwelling older adults. Dutch National Food Consumption Survey-Older adults 2010-2012: National Institute for Public Health and the Environment, 2013.
17. Tieland M, Borgonjen-Van den Berg KJ, van Loon LJC, de Groot LC. Dietary protein intake in community-dwelling, frail, and institutionalized elderly people: scope for improvement. Eur J Nutr 2012; 51(2): 173-9.
18. Stratton RJ, Hackston A, Longmore D, et al. Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. Br J Nutr 2004; 92(05): 799-808.
19. Doorduijn AS, van Gameren Y, Vasse E, de Roos NM. At Your Request® room service dining improves patient satisfaction, maintains nutritional status, and offers opportunities to improve intake. Clin Nutr.
20. Dutch Malnutrition Steering Group. Guideline Screening and and treatment of malnutrition. Amsterdam, 2011.
21. Harris JA, Benedict FG. A biometric study of basal metabolism in man. Washington DC: Carnegie Institute of Washington; 1919.
22. Gaillard C, Alix E, Boirie Y, Berrut G, Ritz P. Are elderly hospitalized patients getting enough protein? J Am Geriatr Soc 2008; 56(6): 1045-9.
23. Wolfe RR, Miller SL, Miller KB. Optimal protein intake in the elderly. Clin Nutr 2008; 27(5): 675-84.
24. Cawood A, Elia M, Stratton R. Systematic review and meta-analysis of the effects of high protein oral nutritional supplements. Ageing Research Reviews 2012; 11: 278-96.
25. Sullivan DH, Sun S, Walls RC. Protein-energy undernutrition among elderly hospitalized patients: A prospective study. JAMA 1999; 281(21): 2013-9.
26. Barton A, Beigg C, Macdonald I, Allison S. A recipe for improving food intakes in elderly hospitalized patients. Clin Nutr 2000; 19(6): 451-4.

27. Wall BT, van Loon LJ. Nutritional strategies to attenuate muscle disuse atrophy. Nutr Rev 2013; 71(4): 195-208.
28. Tieland M, Borgonjen-Van Den Berg KJ, Van Loon LJC, de Groot LCPGM. Dietary protein intake in dutch elderly people: A focus on protein sources. Nutrients 2015; 7(12): 9697-706.

3

Chapter 4



Protein enrichment of familiar foods as an innovative strategy to increase protein intake in institutionalized elderly

Janne Beelen, Nicole M de Roos, Lisette CPGM de Groot

Journal of Nutrition, Health and Aging, 2016

Abstract

Objectives: To increase the protein intake of older adults, protein enrichment of familiar foods and drinks might be an effective and attractive alternative for oral nutritional supplements (ONS). We performed a pilot study to test whether these products could help institutionalized elderly to reach a protein intake of 1.2 gram per kg body weight per day (g/kg/d).
Design: Intervention study with one treatment group (no control group). Dietary assessment was done before and at the end of a 10-day intervention.
Setting: Two care facilities in Gelderland, the Netherlands: a residential care home and a rehabilitation center.
Participants: 22 elderly subjects (13 women, 9 men; mean age 83.0±9.4 years).
Intervention: We used a variety of newly developed protein enriched regular foods and drinks, including bread, soups, fruit juices, and instant mashed potatoes.
Measurements: Dietary intake was assessed on two consecutive days before and at the end of the intervention, using food records filled out by research assistants. Energy and macronutrient intake was calculated using the 2013 Dutch food composition database. Changes in protein intake were evaluated using paired t-tests.
Results: Protein intake increased by 11.8 g/d (P=0.003); from 0.96 to 1.14 g/kg/d (P=0.002). This increase is comparable to protein provided by one standard portion of ONS. The intake of energy and other macronutrients did not change significantly. At the end of the intervention more elderly reached a protein intake level of 1.2 g/kg/d than before (9 vs 4). Protein intake significantly increased during breakfast (+3.7 g) and during the evening (+2.2 g).
Conclusion: Including familiar protein enriched foods and drinks in the menu helped to meet protein recommendations in institutionalized elderly.

Introduction

Many elderly in the Netherlands experience undernutrition. In their report about undernutrition, the Dutch Health Council reports that 33% of the hospitalized elderly, 18-21% of the institutionalized elderly and 12-16% of the elderly receiving home care suffer from undernutrition.[1] Undernutrition is caused by an inadequate intake of calories, protein, or other nutrients needed for tissue maintenance or repair.[2]

The reasons for an inadequate nutrient intake in the elderly are diverse, including anorexia of ageing, changes in food preferences and difficulties in obtaining and preparing food.[3-5] Moreover, elderly people report to have declined appetite feelings [6] and eating meals is no longer a desire but a discipline for many elderly.[7] The elderly especially have an increased risk at an insufficient protein intake because preferential consumption of protein-rich foods may decrease with ageing.[5]

They have, however, also an increased need for proteins due to a reduced ability to use available protein.[8] The current recommended protein intake for elderly over 65 years is the same as for younger adults: 0.8 gram of protein/kg body weight/day (g/kg/d). Many researchers and geriatricians plea for a higher recommended protein intake: 1.2 - 1.5 g/kg/d. They argue that this higher recommendation is not just to prevent deficiencies but also to maintain health and function in the elderly.[8-13] Moreover, recent literature suggests that an intake of 25-30 gram of high quality protein per meal is needed to maximize muscle protein synthesis and maintain muscle mass in elderly people.[11] Recent studies suggest that most elderly do not reach this high intake with their current diet.[14-16] Especially breakfast of Dutch elderly is low in protein content.[14]

Therefore, professionals responsible for nutritional care look for ways to improve protein intake in undernourished elderly. Normally first, they try to increase protein intake by advising protein rich snacks and double sandwich toppings, like cheese or meat. If this is not successful, protein enriched oral nutritional supplements (ONS) are commonly prescribed. However, the effectiveness of ONS on functional improvements is still a matter of debate.[17] When ONS is consumed for prolonged periods, the compliance usually declines; the number of different flavors and textures is too limited to fulfil the elderly's needs and wishes.[18-20]

To fill the gap between regular foods and clinical nutrition, we decided to develop protein enriched food products. As part of the product development phase, we interviewed undernourished elderly to gain consumer insights. We found that the elderly prefer familiar foods that are easy to consume and prepare and that portion sizes should not increase. By enriching foods and drinks that are familiar to the elderly, they can increase their protein consumption without changing their eating habits or increasing their portion sizes. Besides these advantages, these protein enriched familiar products are ready to eat in contrast to commonly used protein powders that have to be added to foods with the risk of decreasing palatability. Moreover, the newly developed products were tested in a consumer panel of healthy elderly who rated them as more palatable than ONS.

If protein enriched products are consumed in the same amount as regular products, protein intake will automatically increase. However, protein enriched products are suggested to be more satiating than iso-caloric carbohydrate enriched products.[21] This might limit the intake of protein enriched products. Another undesired effect could be that the higher protein intake from the enriched products is compensated by choosing low protein foods and drinks during the rest of the day.

Therefore, this pilot study investigated whether protein enriched familiar food products, specifically developed for older adults, enabled them to reach a protein intake of 1.2 g/kg/d. Furthermore, the protein distribution across meals will be assessed. The results of this pilot study will be used to improve products for an intervention study on the health effects of a protein enriched diet in elderly patients.

Methods

Design

This pilot study was performed in the Netherlands in two care facilities from the same care organization. The first facility was a residential care home where elderly people live long-term, and the second facility was a rehabilitation center for temporary stay. A total of 88 elderly resided in the care home, while the rehabilitation center had room for 32 people at once. People in the rehabilitation center were for instance recovering from surgery or stroke. Study participants were recruited from the residents in three ways: by personal information brochures in their mailboxes, by posters in the common areas of the care facilities, and by the nursing staff who asked them if they wanted to participate. Residents had to give written informed consent prior to receiving the nutritional intervention. This pilot study consisted of one intervention group, without having a separate control group. The Wageningen University Medical Ethical Committee approved this study. This study was registered on ClinicalTrials.gov (Identifier: NCT02141256).

Participants

Participants were at least 60 years of age and stayed at one of the care homes. Potential participants were not included when they were cognitively impaired; suffered from dementia; had dysphagia; only received tube feeding; or had dietary protein restrictions due to for example chronic kidney disease or food allergies.

Nutritional intervention

During a 10-day period a variety of newly developed food products were incorporated into the food assortment of the care homes. These included protein enriched foods (e.g. bread, soups, fruit juices, and mashed potatoes) and foods with a naturally high protein content (e.g. veal).

Some of these foods could be used as a replacement of comparable regular foods, such as the bread, soups, mashed potatoes and meat. Other foods were offered as additional choices, such as the protein enriched fruit juices. Most intervention products were offered as an extra option within the regular menu, because we wanted to test whether these products were effective when subjects had free choice, which reflects daily practice. Table 4.1 shows all intervention products, with the variety of flavors and their additional protein content per portion. The protein enriched products were enriched with protein from plant and/or animal origin, e.g. soy and dairy. Participants were completely free to consume the protein enriched products or not, and could consume as much of the foods as they wanted.
The food distribution system differed between the two facilities: the elderly in the care home consumed only their hot meal in the restaurant, while the elderly in the rehabilitation center consumed all three of their meals in the center's restaurant. Juices and snacks were placed in participants' refrigerators, so they could choose themselves if and when to take them.

Table 4.1: Protein enriched intervention products and their additional protein content per portion compared to non-enriched products.

Product	Variety of flavor or type	Additional protein per portion (gram)	Portion size
Bread	Light	5.6	2 slices (27 gram per slice)
	Dark	5.6	2 slices (27 gram per slice)
Soup (without meat)	Mushroom	10	150 mL
	Broccoli	10	150 mL
	Tomato	10	150 mL
Fruit juice	Orange	10	150 mL
	Strawberry-Apple	10	150 mL
	Blue berry-Apple	10	150 mL
Mashed potatoes	-	8.4	150 gram

Outcome measurements

At baseline, a participant's descriptive measures were recorded, including birth date, gender, body weight, height, and risk of malnutrition. Body weight was not expected to change in this short time period and was therefore measured once during the study with a calibrated digital weighing scale to 0.01 kg (SECA weighing scale). When a participant could not stand on the weighing scale, the nursing staff reported body weight that was recently measured with the weighing chair. Body weight was also recorded to calculate the protein intake in g/kg/d. Height was measured to 0.1 cm using a stadiometer (SECA stadiometer). When a participant could not stand up straight, due to physical restraints, lower leg length was measured to 0.1 cm and the formulas of Sienkiewicz-Sizer [22] were used to estimate standing height. These formulas were developed specifically for elderly people. One researcher screened for risk of malnutrition with the Mini Nutritional Assessment Short Form (MNA-SF).

Dietary intake was assessed twice: on two consecutive days a week before the intervention period started, and on the intervention's last two days (days 9 and 10). Three trained research assistants filled out food records with the participants. To prevent inter-rater variability the same research assistant visited the same participant each time. The assistants visited the participants on average 3 times a day to ask the participants what they consumed. This assessment method was chosen to limit recall bias. For the hot meal the procedure was slightly different: research assistants were present during the meal. When a plate was served, each component of the meal was recorded in household measures (amount of spoons or portion sizes). Directly after the hot meal, the participant was asked how much of the served plate was left over.

Consumption of the intervention products (at the end of the intervention) and their corresponding regular products (before the intervention) was calculated in portions per day. Furthermore, dietary intake of energy, macronutrients and food products was calculated with the program Compl-eat (Department of Human Nutrition, Wageningen University), using the 2013 Dutch food composition database.[23] Protein intake was calculated in g/kg/d. This was done per kg actual body weight but also per kg adjusted body weight when BMI was above 27 kg/m^2, because protein recommendations are based on lean body mass. Body weight was adjusted for subjects with a BMI > 27 kg/m^2 to a body weight corresponding with a BMI of 27 kg/m^2.[24] This is in line with the practical guidance for Dutch dietitians when calculating protein requirements. Protein intake in g/kg actual and adjusted body weight per day was compared with the reference intakes of 0.8 and 1.2 g/kg/d. Participants could also comment on a product's taste or texture during the whole intervention period. Comments were recorded and interpreted in a qualitative manner. Comments regarding non-food items such as comments on health were also recorded.

Sample size calculation

Sample size was calculated to detect an increase of 15 gram protein per day as statistically significant. With a SD of 25 gram a minimum of 22 subjects was required (power=0.80, α=0.05). The used SD is slightly lower than the SD in a study conducted in a population of Dutch hospitalized elderly [15], because we expected that our subjects would have a more stable intake. To account for a dropout rate of 10% a sample size of 25 subjects was considered sufficient.

Statistical analysis

Statistical analysis was done using IBM SPSS Statistics Version 22. Descriptive statistics were performed to describe baseline characteristics. All continuous variables are presented as means ± SD. To investigate whether the effect on the protein intake was different in the two different facilities, we used the Univariate General Linear Model (GLM) procedure. The change in protein intake is analyzed using a paired samples T-test. The changed intake of energy and other macronutrients was also analyzed using a paired samples T-test. A $P<0.05$ was considered statistically significant.

Results

From the 88 residents in the care home, 21 were excluded based on their cognitive capabilities. From the 67 eligible people, only 11 wanted to participate. Reasons for not wanting to participate were: they were not interested, they thought it was too exhausting, or they did not want to participate without specifying a reason. In the rehabilitation center, all new guests were informed about the study. In total, 30 people have been informed, until we had 14 participants in this center. In total, 25 participants gave written consent to participate in the study: 11 from the residential care home and 14 from the rehabilitation center. From the 11 participants in the care home, one withdrew before the start of the intervention due to health problems. In the rehabilitation center, one participant was unexpectedly discharged before completion of the baseline measurements and one was critically ill during the last two measurement days. All three subjects were excluded from the statistical analyses, leaving data collected from 22 subjects for statistical analyses. Table 4.2 shows the baseline characteristics of the study population. This study population had a mean age of 83.0 ± 9.4 years. According to the MNA-SF scores, 6 of the 22 participants were undernourished, and 4 were at risk of becoming undernourished.

Table 4.2: Baseline characteristics of study population (n=22; 13 female and 9 male)

	Mean ± SD	**Range**
Age (years)	83.0 ± 9.4	61 – 95
Body weight (kg)	73.4 ± 17.6	46.0 – 116.5
Height (m)	1.64 ± 0.08	1.50 – 1.82
Body Mass Index	27.3 ± 6.0	17.0 – 40.6
MNA-SF score	n (%)	
Normal nutritional status (12-14)	12 (54.5)	
Risk of undernutrition (8-11)	4 (18.2)	
Undernourished (0-7)	6 (27.3)	

First, the consumption of bread, juice, soup, mashed potatoes, and meat was calculated in portions per day before and at the end of the intervention (Table 4.3). For the end measurement, the portions of intervention products were also calculated for these product groups. The consumption of bread increased a little, and at the end of the intervention 2 of the 3 slices bread that were consumed were protein enriched. The protein enriched bread delivered 10.8 g protein. The amount of juice increased due to the intervention juices from 0.5 to 1.2 portions, which increased protein intake with 7 g. Almost all protein delivered via juice, came from the protein enriched juices: 6.7 g. Consumption of soup remained stable, but almost half of it was protein enriched at the end of the intervention: 0.3 of the 0.8 portions in total. More than half of the protein intake from soup was delivered by the intervention soups: 5.3 g of 7.8 g. Mashed potatoes and meat were not consumed in large portions. This can be explained by the multiple choices that were available in the menus.

Table 4.3: Consumed portions per day of bread, juice, soup, mashed potatoes and meat before and at the end of the intervention.

	Before		**Intervention**	
	Portions, mean (range)	Protein delivered (g)	Portions, mean (range)	Protein delivered (g)
Bread [a]	2.5 (0.5-4.5)	8.8	2.9 (1.1-5)	13.3
of which intervention bread products	-	-	1.9 (0-4)	10.8
Juice [b]	0.5 (0-3.2)	0.4	1.2 (0-4)	7.0
of which intervention juices	-	-	0.7 (0-3)	6.7
Soup [c]	0.7 (0-1.4)	4.4	0.8 (0-1.4)	7.8
of which intervention soups	-	-	0.3 (0-1)	5.3
Mashed potatoes	0.13 (0-1)	0.9	0.34 (0-1)	2.8
of which intervention mashed potatoes	-	-	0.16 (0-1)	1.7
Meat	0.73 (0-2)	12.8	0.69 (0-2)	14.2
of which intervention meat	-	-	0.16 (0-1)	2.9

[a] 1 portion is 1 slice of bread (regular bread: 35 g; protein enriched bread: 27 g), [b] 1 portion is 150 mL, [c] 1 portion is 200 mL

* Baked beans, chocolate cake, apple strudel and crackers were not consumed on the assessment days of the intervention period, and are therefore not listed in this table.

Facility did not affect intake and the data were therefore analyzed as one group. Mean protein intake increased by 11.8 grams per day (P = 0.003). This is equal to 0.18 g/kg/d (P = 0.002). Energy intake did not significantly change during the intervention period, nor did fat or carbohydrate intake (Table 4.4).

Table 4.4: Dietary intake before and at the end of the intervention and the difference (n=22)

	Before	Intervention	Difference	P-value
Energy (kJ/d)	6856 ± 1878	7139 ± 1623	283	0.336
Energy (kcal/d)	1635 ± 451	1706 ± 389	71	0.314
Protein (g/d)	64.5 ± 17.7	76.3 ± 18.9	11.8	0.003‡
Protein (g/kg/d)*	0.89 ± 0.20	1.06 ± 0.20	0.16	0.003‡
Protein (g/kg/d)†	0.96 ± 0.19	1.14 ± 0.20	0.18	0.002‡
Fat (g/d)	69.4 ± 31.7	75.7 ± 26.8	6.3	0.189
Carbohydrates (g/d)	170.5 ± 34.9	158.6 ± 37.3	-11.9	0.155

* Unadjusted body weight was used

† Body weight is adjusted when BMI > 27 kg/m^2

‡ P < 0.05 indicates significance

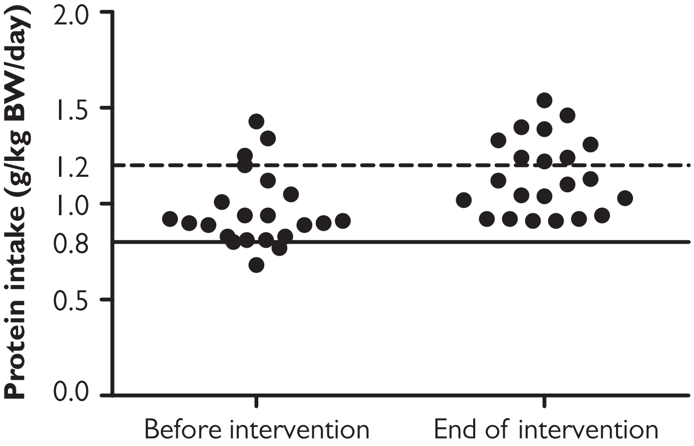


Figure 4.1: Column scatter of individual protein intake (g/kg/d; based on adjusted body weight if BMI > 27kg/m^2, this is common practice in the Netherlands) before and at the end of the intervention period.

Figure 4.1 shows the individual protein intakes in g per kg adjusted body weight per day of the participants before and at the end of the intervention period. The horizontal lines represent the current recommendation of 0.8 and the proposed new recommendation of 1.2 g/kg/d. Before the intervention, 19 subjects reached an intake of 0.8 g/kg/d, but only 4 reached an intake of 1.2 g/kg/d. At the end of the intervention, all subjects reached a protein intake of 0.8 g/kg/d and 9 subjects reached an intake of 1.2 g/kg/d. Only 4 subjects had lower protein intakes after the intervention than before. Using actual body weight resulted in slightly lower protein intakes per kg body weight and fewer subjects reaching the recommendations: before the intervention, 15 subjects reached an intake of 0.8 g/kg/d, whilst 2 reached an intake of 1.2 g/kg/d. At the end of the intervention, 21 subjects reached an intake of 0.8 g/kg/d, and 5 subjects reached an intake of 1.2 g/kg/d.

To see if the mean change in protein intake was not heavily dependent on a few subjects, we looked at individual differences in protein intake. We found that only 4 subjects had a lower protein intake at the end of the intervention than before the intervention (data not shown). The rest of the subjects showed an increase in protein intake, with 12 subjects having an increased intake of at least 10 grams.

Finally, we calculated protein intake during six different meal moments: breakfast, during the morning, lunch, during the afternoon, dinner, and during the evening (Figure 4.2). As expected, dinner provided the major part of proteins: 29.1 g before and 28.6 g at the end of the intervention period. Only two meal moments significantly increased in protein content: breakfast increased from 12.2 to 16.0 g ($P = 0.010$) and the snack moment during the evening increased from 2.6 to 4.8 g ($P = 0.020$). Only dinner provided more than 25 g protein but this was not influenced by the intervention products.

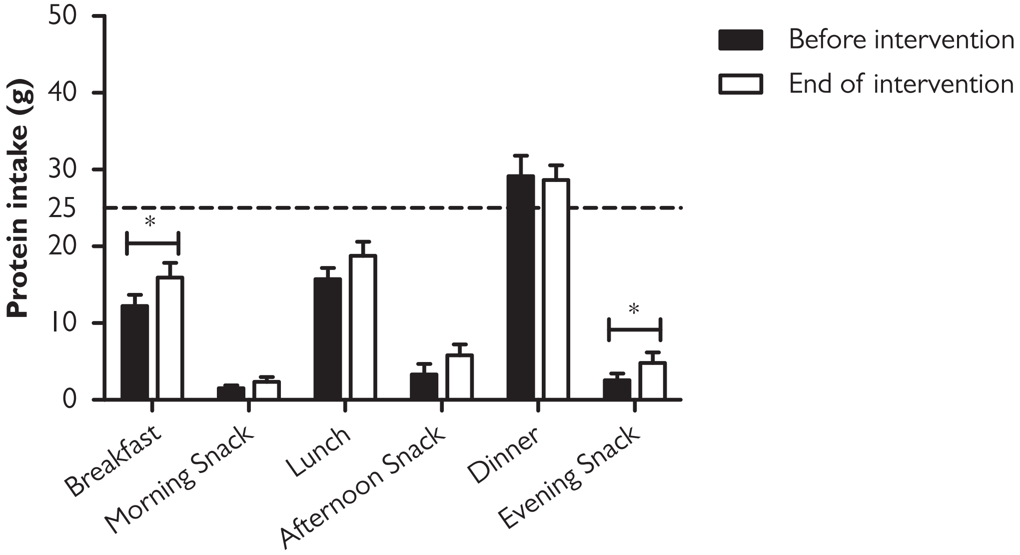


Figure 4.2: Protein intake per meal moment in g (mean and SEM are shown, *indicates a P <0.05).

Discussion

The results of this 10-day intervention study indicate that the dietary protein intake of institutionalized elderly can be increased by 11.8 grams per day with just a few protein enriched products. At the end of the intervention all elderly reached a protein intake of 0.8 g/kg/d and more elderly met the newly proposed recommendation of 1.2 g/kg/d than before (9 vs 4). The two meal moments that increased most in protein content were breakfast (+3.7 grams) and the evening snack moment (+2.2 grams). We found no evidence for a more satiating effect of the protein enriched foods, because protein intake from their regular diet remained stable.
The increased protein intake we found is in line with other studies, however ours is one of the few studies that uses protein enriched products instead of Oral Nutritional Supplements (ONS). A recent study of Stelten et al. used protein enriched bread and drinking yoghurt to increase protein intake in acute hospitalized elderly. The mean protein intake in the intervention group was 1.1 g/kg/d (75.0 g/d) compared to 0.9 g/kg/d (58.4 g/d) in the control group.[25] The same protein enriched bread and drinking yoghurt were tested in older adults in a rehabilitation center for three consecutive weeks. The intervention group had a protein intake of 1.6 g/kg/d (115.3 g/d) while the control group's intake was 1.1 g/kg/d (72.5 g/d). The combination of protein enriched bread and drinking yoghurt was very effective in reaching an intake of 25 g protein during breakfast and lunch which is suggested to be beneficial for conserving muscle mass in older adults.[26] Our study, however, reflects daily practice in Dutch care centers. Participants were not obliged to consume only the intervention products but were free to choose from the extensive menu options in

4

both care centers. In addition, we offered a larger variety on product types and flavors then the aforementioned studies. Adding protein to a normal diet was also done in a study of Iuliano et al. This study included extra portions of dairy in the meals and snacks, and a difference of 25 g protein per day was reached.[27] Studies that used ONS as a nutritional strategy, found inconsistent results. Neelemaat et al. found an increase of 11 g of protein per day after supplying two portions of ONS for 3 months after hospital discharge.[15] Another study that used a nutrient enriched drink found an increase of 6.3 g/d with two portions of this enriched drink provided.[28] In the current study, we found that using protein enriched familiar products had similar or larger effects than these studies using oral nutritional supplements. The increase in protein intake we found is comparable to most standard portions of ONS.

One of the strengths of this study is that the protein enriched products replaced products that older adults already use. This means they do not have to consume an extra serving of ONS or an extra serving of dairy or meat, as they had to do in other studies.[15,27,28] As such, implementing this new diet was relatively easy. Also, using two different types of facilities was a strength because this provided insights into the role of free choice by the residents and the role of the awareness and actions of the personnel. This provided a realistic view of problems that could be encountered during the implementation of our protein enriched foods. It appeared that personnel was sometimes unaware of who was currently in the study and had to be offered the intervention products. The researchers observed during the hot meal that the soups, juices, mashed potatoes, and veal were only consumed when offered actively but were well accepted. This means that the awareness, attitude and actions of the personnel may greatly affect the protein intake of institutionalized elderly.

Regarding the elderly themselves, the screening for undernutrition showed that in the care home, only one participant was undernourished and two were at risk of undernutrition. In the rehabilitation center five participants were undernourished and two were at risk of undernutrition. Considering this, we think protein enriched products are especially important for rehabilitating elderly. It is known that older patients need more protein during recovery.[8,12] However, the rehabilitating elderly seemed to need more motivation or guidelines to actually consume the intervention products. This might be explained by their temporary stay while the elderly in the care home were in there own home environment and felt more at ease using products whenever they wanted. Because of the small number of participants, we should be careful when extrapolating our results to all institutionalized elderly. The small number of participants may have been the most enthusiastic, and health conscious residents. To avoid selection bias, we wanted to give all residents the intervention diet, but this raised an ethical discussion about the free choice of residents to participate in such a study. Furthermore, it can be argued that our cognitive adequate subjects do not 100 percent reflect the usual care home residents. From all 88 residents, 21 (24%) were excluded due to cognitive impairment, which is quite a large proportion. However, including cognitive impaired elderly was not possible due to the dietary assessment method which depends on memory. Therefore, the effectiveness of these products should be tested in a larger group. We are aware that the used method for dietary assessment might not be ideal. We needed an assessment method that would measure actual intake without depending on a participant's memory and cognitive abilities too much and without interfering with their food choices. For these reasons, a self-recorded food diary was not an option nor was a 24hr recall. We discussed this with several dietary assessment experts, and came to the conclusion that multiple visits per day on which a research assistant recorded food intake would be the best method. With this method the elderly just had to recall their last meal and in between snack moments. We visited the participants multiple times a day, which may have influenced the eating behavior of the participants. However, this bias does not play a role because we looked at the difference in intake between the two periods in the same subjects.

During the 10 day intervention period, subjects gave their opinion about the intervention products. Particularly the snacks, including sweet and savory pastry and baked beans, were not accepted well, and it became clear that better tasting alternatives need to be developed in the future. The change from normal bread to protein enriched bread was easily made and well accepted. We also saw an increase in juice consumption, this might be explained by the fact that the juices were freely available in the participants' refrigerators in the intervention period only. Furthermore, a larger variety of flavors and types of products can increase the liking and consumption of the products since taste and texture preferences are different per individual.[29] This might also contribute to compliance to these protein enriched products on the long term.

Conclusion

In conclusion, including familiar protein enriched foods and drinks in the menu helped to meet protein recommendations in institutionalized elderly. Protein enriched familiar food products seem to be a good alternative to nutritional supplements for institutionalized elderly to reach their protein requirements.

Acknowledgements

The authors thank the participants, the staff of the participating centers of Opella, and all research assistants for their assistance during data collection.

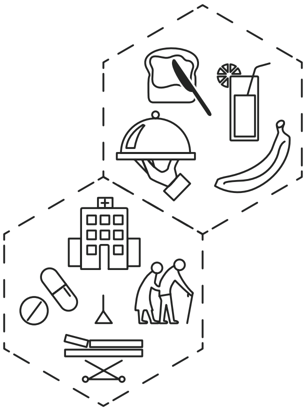
References

1. Health Council of the Netherlands. Undernutrition in the elderly. The Hague, 2011.
2. White JV, Guenter P, Jensen G, et al. Consensus Statement: Academy of Nutrition and Dietetics and American Society for Parenteral and Enteral Nutrition: Characteristics Recommended for the Identification and Documentation of Adult Malnutrition (Undernutrition). Journal of Parenteral and Enteral Nutrition 2012; 36(3): 275-83.
3. Morley JE. Undernutrition in older adults. Fam Pract 2012; 29: i89-i93.
4. Soenen S, Chapman IM. Body weight, anorexia, and undernutrition in older people. J Am Med Dir Assoc 2013; 14(9): 642-8.
5. Volpi E, Campbell WW, Dwyer JT, et al. Is the Optimal Level of Protein Intake for Older Adults Greater Than the Recommended Dietary Allowance? The Journals of Gerontology Series A: Biological Sciences and Medical Sciences 2013; 68(6): 677-81.
6. Mudge AM, Ross LJ, Young AM, Isenring EA, Banks MD. Helping understand nutritional gaps in the elderly (HUNGER): a prospective study of patient factors associated with inadequate nutritional intake in older medical inpatients. Clin Nutr 2011; 30(3): 320-5.
7. Mahler M, Sarvimäki A. Appetite and falls: Old age and lived experiences. International Journal of Qualitative Studies on Health and Well-being 2012; 7: 10.3402/qhw.v7i0.11540.
8. Bauer J, Biolo G, Cederholm T, et al. Evidence-Based Recommendations for Optimal Dietary Protein Intake in Older People: A Position Paper From the PROT-AGE Study Group. J Am Med Dir Assoc 2013; 14(8): 542-59.
9. Gaffney-Stomberg E, Insogna KL, Rodriguez NR, Kerstetter JE. Increasing dietary protein requirements in elderly people for optimal muscle and bone health. J Am Geriatr Soc 2009; 57(6): 1073-9.
10. Houston DK, Nicklas BJ, Ding J, et al. Dietary protein intake is associated with lean mass change in older, community-dwelling adults: the Health, Aging, and Body Composition (Health ABC) Study. Am J Clin Nutr 2008; 87(1): 150-5.
11. Paddon-Jones D, Rasmussen BB. Dietary protein recommendations and the prevention of sarcopenia: Protein, amino acid metabolism and therapy. Curr Opin Clin Nutr Metab Care 2009; 12(1): 86-90.
12. Wolfe RR, Miller SL, Miller KB. Optimal protein intake in the elderly. Clin Nutr 2008; 27(5): 675-84.
13. Morais J, Chevalier S, Gougeon R. Protein turnover and requirements in the healthy and frail elderly. J Nutr Health Aging 2006; 10(4): 272.
14. Tieland M, Borgonjen-Van den Berg KJ, van Loon LJC, de Groot LC. Dietary protein intake in community-dwelling, frail, and institutionalized elderly people: scope for improvement. Eur J Nutr 2012; 51(2): 173-9.
15. Neelemaat F, Lips P, Bosmans JE, Thijs A, Seidell JC, van Bokhorst-de van der Schueren MAE. Short-term oral nutritional intervention with protein and & vitamin D decreases falls in malnourished older adults. J Am Geriatr Soc 2012; 60(4): 691-9.
16. Vikstedt T, Suominen MH, Joki A, Muurinen S, Soini H, Pitkälä KH. Nutritional status, energy, protein, and micronutrient intake of older service house residents. J Am Med Dir Assoc 2011; 12(4): 302-7.
17. Milne AC PJ, Vivanti A, Avenell A. . Protein and energy supplementation in elderly people at risk from malnutrition. Cochrane Database of Systematic Reviews 2009; (2).
18. Bruce D, Laurance I, McGuiness M, Ridley M, Goldswain P. Nutritional supplements after hip fracture: poor compliance limits effectiveness. Clin Nutr 2003; 22(5): 497-500.
19. Lad H, Gott M, Gariballa S. Elderly patients compliance and elderly patients and health professional's, views, and attitudes towards prescribed sip-feed supplements. J Nutr Health Aging 2005; 9(5): 310-5.
20. Methven L, Rahelu K, Economou N, et al. The effect of consumption volume on profile and liking of oral nutritional supplements of varied sweetness: Sequential profiling and boredom tests. Food Qual Prefer 2010; 21(8): 948-55.
21. Bertenshaw EJ, Lluch A, Yeomans MR. Satiating effects of protein but not carbohydrate consumed in a between-meal beverage context. Physiol Behav 2008; 93(3): 427-36.
22. Sienkiewicz-Sizer F, Noss-Whitney, E.,. Nutrition Concepts and controvercies. seventh edition ed: Belmont; 1997.
23. RIVM. Dutch Food composition table (NEVO-tabel 2013). Bilthoven; 2013.
24. Weijs PJM, Sauerwein HP, Kondrup J. Protein recommendations in the ICU: g protein/kg body weight – which body weight for underweight and obese patients? Clin Nutr 2012; 31(5): 774-5.
25. Stelten S, Dekker I, Ronday E, et al. Protein-enriched ‘regular products’ and their effect on protein intake in acute hospitalized older adults; a randomized controlled trial. Clin Nutr 2014.

26. van Til A, Naumann E, Cox-Claessens I, Kremer S, Boelsma E, de van der Schueren MA. Effects of the daily consumption of protein enriched bread and protein enriched drinking yoghurt on the total protein intake in older adults in a rehabilitation centre: A single blind randomised controlled trial. J Nutr Health Aging 2014; 19(5): 525-30.
27. Iuliano S, Woods J, Robbins J. Consuming two additional serves of dairy food a day significantly improves energy and nutrient intakes in ambulatory aged care residents: A feasibility study. J Nutr Health Aging 2013; 17(6): 509-13.
28. Manders M, de Groot C, Blauw Y, et al. Effect of a nutrient-enriched drink on dietary intake and nutritional status in institutionalised elderly. Eur J Clin Nutr 2009; 63(10): 1241-50.
29. van der Zanden LDT, van Kleef E, de Wijk RA, van Trijp HCM. Examining heterogeneity in elderly consumers' acceptance of carriers for protein-enriched food: A segmentation study. Food Qual Prefer 2015; 42(0): 130-8.

4

Chapter 5



Protein-enriched familiar foods and drinks improve protein intake of hospitalized older patients: a randomized controlled trial

Janne Beelen, Emmelyne Vasse, Nancy Janssen, André Janse, Nicole M de Roos, Lisette CPGM de Groot

Submitted

Abstract

Background & aims: Adequate protein intake is important in preventing and treating undernutrition. Hospitalized older patients are recommended to consume 1.2-1.5 g of protein per kg body weight per day (g/kg/d) but most of them fail to do so. Therefore, we investigated whether a range of newly developed protein-enriched familiar foods and drinks were effective in increasing protein intake of hospitalized older patients.

Methods: This randomized controlled trial involved 147 patients of ≥65 years (mean age: 78.5 ± 7.4 years). The control group (n=80) received the standard energy and protein rich hospital menu. The intervention group (n=67) received the same menu with various protein-enriched intervention products replacing regular products. Macronutrient intake was compared between the two groups by using Independent T-tests and Mann Whitney U-tests.

Results: In the intervention group 30% of total protein was provided by the intervention products. The intervention group consumed 105.7 ± 34.2 g protein compared to 88.2 ± 24.4 g in the control group ($p<0.01$); corresponding with 1.5 vs 1.2 g/kg/d ($p<0.01$). More patients in the intervention group than in the control group reached a protein intake of 1.2 g/kg/d (79.1% vs 47.5%). Protein intake was significantly higher in the intervention group at breakfast, during the morning between breakfast and lunch, and at dinner.

Conclusions: This study shows that providing protein-enriched familiar foods and drinks, as replacement of regular products or as additions to the hospital menu, better enables hospitalized older patients to reach protein intake recommendations.

5

Introduction

The number of older adults within our society is rapidly increasing.[1] As people get older they often face multiple chronic diseases and physiological changes that impair food intake and increase the risk of undernutrition.[2] Depending on the definition used, the prevalence of undernutrition among hospitalized older adults in the Netherlands is estimated to be 18 to 33%.[3] Undernutrition is associated with several adverse clinical outcomes such as an impaired immune function, delayed wound healing, prolonged treatment duration, and a higher chance of readmission.[4,5] Moreover, as a result of an inadequate dietary intake combined with reduced physical activity, older adults are prone to develop sarcopenia, the age-related loss of muscle mass and function.[6] An adequate dietary protein intake plays an essential role in the prevention and treatment of undernutrition and sarcopenia. Especially during illness, protein needs are higher due to inflammatory responses.[7] Recent recommendations for older adults who suffer from acute or chronic diseases are set at a protein intake of 1.2-1.5 g per kg body weight per day (g/kg/d).[8] However, the intake of hospitalized and recently discharged older adults averages 0.9 g/kg/d, which is well below this recommendation.[9,10]

In general, eating more to reach the recommended protein intake is difficult for older adults. Many older adults experience a loss of appetite due to impaired senses of taste and smell due to physiological changes or side effects of medicines, and they feel satiated sooner than they did when they were younger. This situation is worsened when they are acutely or chronically ill.[2,11,12]

When the recommended protein intake is not achieved through regular foods, oral nutritional supplements (ONS) are often prescribed.[11] In practice, their effect on intake may be limited by poor compliance due to a low palatability, and negative effects on satiety.[11,13]

Extra measures to increase the intake of patients were mainly focused on energy and protein rich menus or meals. Despite these efforts, the majority of the older patients still do not reach their recommended protein intake.[14,15]

Enriching familiar and commonly consumed products might be more effective in increasing protein intake. Recently, a trial by Stelten et al. already found promising results with just two protein-enriched regular foods (bread and drinking yoghurt) in acute hospitalized elderly patients. However, most patients still did not reach the recommended intake of 1.2 g/kg/d.[9]

To obtain a more substantial effect and to provide more choice during the whole day, a consortium of food companies, nutrition researchers, and health professionals developed a larger variety of protein-enriched familiar foods, tailored to the needs and preferences of older adults. A pilot study with a small range of these products showed an increased protein intake (±12 gram) among institutionalized elderly.[16]

In this study, we investigated whether replacing regular foods and drinks by protein-enriched varieties would increase the protein intake of hospitalized older patients.

Materials and Methods

This study was designed as a randomized controlled trial (RCT) with two parallel treatment arms in hospital Gelderse Vallei in Ede, the Netherlands. The study is registered on ClinicalTrials.gov (Identifier: NCT02213393).

Subjects

Patients were recruited between October 1, 2014 and April 1, 2015. All patients of 65 years and older admitted to the departments of geriatrics/internal medicine or pulmonary medicine were screened for study eligibility. Patients were excluded if their hospital stay was expected to be shorter than 4 days, or if they were terminally ill, had a food allergy or intolerance that restricted them from receiving the standard energy and protein rich menu or the protein-enriched intervention products, had an estimated glomerular filtration rate eGFR ≤ 30 mL/min/1.73m^2, had communication difficulties because of aphasia or not understanding the Dutch language, were diagnosed with delirium, or were at risk of developing refeeding syndrome according to the hospital screening tool. Eligible patients were asked to participate in the study within the first 2 days of their hospital stay and signed a written informed consent to gather information from their medical record and ordering data from the meal service system. Patients with cognitive impairment could participate in the study, but written informed consent had to be provided by a legal representative of the patient. The Medical Ethics Research Committee of Wageningen University gave approval for this study.

Nutritional intervention

After inclusion, subjects were randomly assigned to one of the two treatment groups. Randomization was executed by an independent person by using a statistical program, with permuted blocks of size 4, stratified by gender and hospital department of admission (pulmonary medicine, and geriatric and internal medicine). The intervention started within 2 days after hospital admission and continued until the end of a patient's hospital stay. The control group received the standard energy and protein-rich hospital menu (control menu) for patients aged 65 years and older admitted to these departments. In this menu, high-protein deserts and protein-rich snacks, such as salmon on toast, are available. The intervention group received the same standard menu except that regular products were replaced by intervention products in case of bread, soup, beverages, beef, mashed potatoes, and ice cream. The cakes, snack size veal meat balls, and dairy drinks were additional options added to the intervention menu (Table 5.1). In practice, this resulted in an adjusted menu for the intervention group (intervention menu). To verify the protein content of the intervention products, chemical analyses were done (Kjeldahl method). All measured protein levels were within a margin of 5% of the protein content as provided by the manufacturers and shown in Table 5.1. Part of the intervention products had been tested and

proven to be well-accepted in a pilot study in a care home and rehabilitation center.[16]
Hospital Gelderse Vallei offers At Your Request® room service to their patients, which means that patients have free choice from an extensive menu between 7am and 7pm. More details on this meal service system can be found elsewhere.[17] All ordered food products were stored in the database of the Menu Management System (MMS). This database also included the nutritional values of all available food products per serving size. In case of composite dishes, the nutritional value was calculated according to the recipe and nutritional value of each separate ingredient. If patients consumed something that was not ordered through the meal service system, such as foods and drinks brought by family, these products were not included in the ordering data.

Outcome measurements

Characteristics:

The following baseline characteristics were collected from the patient's medical record: age, gender, admission ward, medical diagnosis for admission, score on the Malnutrition Universal Screening Tool (MUST) at hospital admission, hemoglobin level (mmol/L) and vitamin D status (nmol/L). Hemoglobin and vitamin D levels were recorded to obtain an overall impression of health and nutritional status of the patient. Body weight was measured a day before hospital discharge twice with a calibrated digital scale to 0.01 kg (SECA scale). When the two measurements were more than 0.1 kg apart, a third measurement was done. Then, the mean body weight of the two or three measurements was reported. When a participant could not stand on the scale, body weight was measured with a chair scale. Height was measured with a stadiometer (SECA stadiometer) or when a participant could not stand up straight, the height recorded in the medical record was used. We checked whether the measured height differed from the height in the medical record for the subjects of whom we had both numbers (n=97). The medical record overestimated height by 2 cm on average, therefore final height was calculated by subtracting 2 cm from the medical record's height for those subjects without an actual measurement. BMI was calculated by dividing body weight by squared height. Length of hospital stay in days was recorded from the medical record after a patient was discharged. At the day before discharge, hand grip strength was measured using a hand dynamometer (Lafayette Instrument Company). Three consecutive measurements were done with alternating both hands and were recorded to the nearest 0.5 kg and the maximum strength effort was reported for the dominant hand.

Table 5.1: Nutritional content of the protein-enriched intervention products (per portion).

Product group	Product options	Portion size	Energy (kcal)	Protein (g)	Carbohydrates (g)	Fat (g)
Bread	Brown whole-wheat	35 g	87	6.3	9.7	2.2
	Dark whole-wheat	35 g	87	5.8	10.2	2.0
	Light whole-wheat	35 g	93	5.8	11.9	2.1
	Raisin bread roll	50 g	141	5.8	23.8	2.0
	Brown bread roll	50 g	141	7.9	19.2	2.9
Cakes	Apple cake	65 g	294	9.9	34.1	13.1
	Cherry cake	65 g	295	9.9	34.2	13.1
	Raspberry cake	65 g	295	9.9	34.2	13.1
Dairy drinks	Forest fruits	150 ml	138	10.1	21.0	1.5
	Raspberry- Strawberry	150 ml	138	10.1	21.0	1.5
	Tropical	150 ml	138	10.1	21.0	1.5
Fruit juices	Apple- Strawberry	150 ml	82	10.1	9.6	0.0
	Apple- Blueberry	150 ml	82	10.1	9.6	0.0
	Orange	150 ml	88	10.1	11.3	0.3
	Forest fruit	200 ml	113	10.6	17.6	0.0
Ice cream	Forest fruits	100 ml	144	10.0	26.0	0.0
	Raspberry- Strawberry	100 ml	144	10.0	26.0	0.0
Mashed potatoes		150 g	125	10.5	17.2	1.6
Meat	Veal meatball	80 g	202	19.8	0.8	13.3
	Veal sausage	80 g	191	18.9	0.4	12.6
	Veal blade	80 g	137	22.0	0.8	5.0
	Snack size veal meatballs	50 g	126	12.4	0.5	8.3
Soups	Broccoli- Cauliflower	150 ml	91	10.1	3.6	4.5
	Mushroom	150 ml	96	10.1	3.8	4.5
	Tomato	150 ml	98	10.1	6.6	3.5

* According to chemical analyses (with Kjeldahl-method): all measured protein levels were within 5% of the protein content as provided by the manufacturers.

Nutrient intake on day 4 of hospitalization:

The primary outcome of this study was protein intake on day 4 of hospitalization in g/d and in g/kg/d. We chose the fourth day of hospitalization because this is in accordance with the performance indicator on treatment of malnutrition of the Dutch Health Care Inspectorate.[18,19] We used the MMS ordering data to calculate energy (in kcal) and macronutrients (in grams) intake of each patient per day. For each patient, protein intake in g/kg/d was calculated by dividing total protein intake in grams by bodyweight. Protein intake in grams per mealtime was also calculated. Mealtimes were pragmatically based on the ordering time; it was not possible to split meals into bread meals and hot meals.

Protein needs were set at 1.2 g/kg/d and were calculated per patient. For patients with a BMI ≥ 30 kg/m^2 we used an adjusted body weight that corresponded with the patient's height and a BMI of 27.5 kg/m^2.[20] We calculated how many patients per group reached their protein needs.

Consumption of products was reported in portion sizes per patient and the contribution to protein intake of a food group and the intervention products was calculated per patient for both groups. Food groups were based on the Dutch food composition table 2013.[21] Furthermore, the contribution to protein intake (in %) of the intervention products in the intervention group was calculated.

To assess whether we could use the MMS ordering data as a proxy for intake, we did a validation study with 24h recalls to measure actual intake on day 4 in a sub sample of the study population. For 41 patients a 24h recall was completed and could be used to validate the ordering data on day 4. These 41 patients were comparable to the whole study population for age and gender (data not shown). The ordering data from the MMS database were used as a basis to conduct the recall: for each ordered item patients were asked whether everything was consumed or how much of the portion was left over. Food and drinks that were consumed but not ordered via At Your Request®, were recorded in household measures and the Dutch food consumption table 2013 was used to calculate nutritional content.

Bland-Altman plots (not shown) were used to check for agreement between the two methods. We found that the MMS ordering data overestimated protein intake with 7.1 grams compared to the 24h recalls. The bias was not proportional and not different for the two intervention groups ($p=0.169$). Because of the acceptable and systematic mean difference between the two methods we decided that the MMS ordering data could be used as a proxy for intake data on a group level.

Sample size

To detect a clinically relevant difference in protein intake of 0.3 g/kg body weight (e.g. from 0.9 to 1.2 g/kg/bodyweight), 22 patients per group would be needed (using a power of 80%, an α of 0.05 and a standard deviation (SD) of 0.35 based on the unpublished results of an observation study on protein intake of 80 older patients in hospital Gelderse Vallei (Chapter 3). However, we included more patients because this study was part of a longer study in which hospital patients who fulfilled stricter criteria were followed up to 24 weeks after hospital discharge. For this longer study, a sample size calculation was performed to determine the number needed to show significant effects in physical recovery. We needed 70 patients for this follow-up study and therefore we continued including patients in the current hospital study until enough patients could start with the follow-up study. This resulted in more patients for this study than needed according to the sample size calculation.

Statistical analysis

Statistical analysis was done using IBM SPSS Statistics Version 22, conform a predefined analysis plan. Subjects that gave informed consent but received tube feeding or total parenteral nutrition within 2 days of admission were excluded from analyses. Descriptive statistics were performed to describe baseline characteristics and are presented as mean ± standard deviation. The differences in macronutrient intake between the two intervention groups were analyzed by using an independent T-test or with a non-parametric Mann Whitney U-test depending on the data distribution. Statistical significance was set at $p<0.05$.

Results

During the study period of 6 months, 860 patients were screened for eligibility and 159 patients gave consent to participate. The number of participants that was excluded from the analyses, was different between groups: in the control group only 2 patients were excluded, while in the intervention group 10 patients were excluded from analyses. This was mostly due to earlier discharge from the hospital than expected beforehand: both excluded patients in the control group and 5 from the intervention group. Another 5 patients in the intervention group were excluded from analyses due to various reasons, none of them related to the intervention products. Finally, data of 147 patients could be used for the analyses; 80 subjects in the control group and 67 patients in the intervention group (Figure 5.1 shows a flow diagram of the inclusion process).

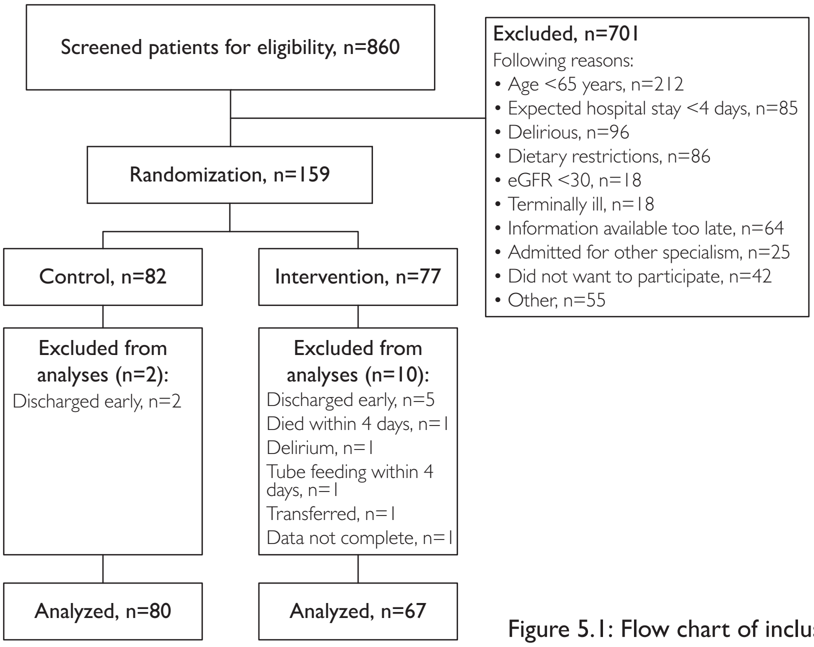


Figure 5.1: Flow chart of inclusion of participants.

The study subjects had a mean age of 78.5 ± 7.4 years, and were mostly admitted to the pulmonary medicine ward with mostly lung disease related reasons for hospital admission (Table 5.2). Education level was low in most patients in both groups. Mean length of stay was 9 days in both groups. Maximum hand grip strength was comparable between groups: 25.4 ± 12.3 kg in the control group and 26.9 ± 12.7 kg in the intervention group.

Table 5.2: Baseline characteristics.

	Control (n=80)	**Intervention (n=67)**
Age (years), mean± SD	79.2 ± 7.0	77.7 ± 7.8
Female, n (%)	44 (55.0)	37 (55.2)
Male, n (%)	36 (45.0)	30 (44.8)
Height (m), mean± SD	1.66 ± 0.09	1.65 ± 0.09
Body weight (kg), mean± SD	75.5 ± 17.3	72.3 ± 16.6
BMI (kg/m²), mean± SD	27.1 ± 5.3	26.6 ± 6.4
Vitamin D (nmol/L), mean ± SD [a]	50.7 ± 26.7	64.2 ± 32.5
Hemoglobin (mmol/L), mean ± SD [b]	8.3 ± 1.3	8.1 ± 1.2
Admission Ward, n (%)		
Geriatric and internal medicine	29 (36.3)	23 (34.3)
Pulmonary medicine	51 (63.7)	44 (65.7)
Medical diagnosis for admission, n (%)		
Exacerbation COPD, Asthma	18 (22.5)	21 (31.3)
Lung infection, Lung inflammation	13 (16.3)	8 (11.9)
Other pulmonary diseases (e.g. Pulmonary embolism, Pneumosepsis, Pneumothorax)	24 (30.0)	18 (26.9)
Other inflammation or infection (not lung)	4 (5.0)	2 (3.0)
Cognitive problems	2 (2.5)	5 (7.5)
Malaise	10 (12.5)	4 (6.0)
Other	9 (11.3)	9 (13.4)
MUST score, n (%)		
MUST 0	62 (77.5)	43 (64.2)
MUST 1	9 (11.3)	9 (13.4)
MUST ≥2	9 (11.3)	15 (22.4)

[a] measured in 37 control patients and 35 intervention patients.

[b] data of 1 intervention patient was missing.

In the intervention group 30% of total protein was provided by the intervention products. Protein-enriched bread products provided on average 11.9 g protein, and the protein-enriched fruit juices provided on average 6.8 g protein per patient. Table 5.3 shows the consumption of all intervention products and their contribution to protein intake. Overall, the number of portions remained the same but the amount of protein was higher in the intervention group as a result of the consumption of the intervention products.

ONS was consumed by only 16 patients (8 in each group) who used on average 1.8 portions each. The total contribution of ONS to protein intake was therefore low (Table 5.3).

Table 5.3: Protein intake from food groups, including intervention products: consumed number of portions and the amount of protein (g).

	Control		**Intervention**	
Product groups / Products	**Portions (n)**	**Protein (g)**	**Portions (n)**	**Protein (g)**
Bread	2.5	10.3	2.5	15.9
of which protein-enriched bread products	-	-	1.4	11.9
Drinks (non-dairy)	4.5	1.8	4.4	8.8
of which protein-enriched fruit juices	-	-	0.7	6.8
Meat	1.3	14.3	1.3	14.4
of which veal products	-	-	0.2	3.9
Dairy	3.7	19.6	3.7	23.2
of which protein-enriched dairy drinks and ice cream	-	-	0.3	2.5
Soups	0.9	1.3	0.8	2.8
of which protein-enriched soups	-	-	0.2	2.0
Cakes and pastry	0.7	1.8	0.8	4.3
of which protein-enriched cakes	-	-	0.3	3.1
Potatoes	0.8	1.7	0.6	2.1
of which protein-enriched mashed potatoes	-	-	0.1	0.9
Oral Nutritional Supplements (ONS)	0.2	2.3	0.2	3.1
Composite dishes	0.5	7.8	0.4	6.0
Nuts, seeds and snacks	0.7	4.2	0.7	4.8
Cheese	1.3	10.6	0.9	7.5
Fish	0.4	5.2	0.4	6.2
Total	**-**	**88.2**	**-**	**105.7**
of which intervention products	**-**	**-**	**-**	**31.4**

N.B.: These food groups all provided at least 2.5% of total protein intake per group. Portion sizes are the same for both groups.

5

Intake data for energy and macronutrients are presented in Table 5.4. The intervention group consumed 17.5 g protein more than the control group did (105.7 ± 34.2 vs 88.2 ± 24.4 g/d, p<0.01). This corresponds with a higher protein intake in g/kg body weight in the intervention group compared to the control group: 1.51 vs 1.22 g/kg body weight (p<0.01). Energy (kcal and kcal/kg) was significantly higher in the intervention group, while carbohydrate and fat intake did not differ between groups.

In the intervention group 79% of the patients reached a protein intake of 1.2 g/kg/d, against only 48% in the control group (Table 5.4). Figure 5.2 shows the individual protein intake for each patient in g/kg for both groups compared to the recommended level of 1.2-1.5 g/kg.

Table 5.4: Energy and macronutrient intake on day 4 (mean ± SD), protein intake per meal occasion, and number of patients that reached recommended protein intake levels.

	n 80	**Control**	**n** 67	**Intervention**	***p***
Protein (g)		88.2 ± 24.4		105.7 ± 34.2	**p<0.01[a]**
Protein (g/kg)		1.22 ± 0.43		1.51 ± 0.53	**p<0.01[a]**
Protein (EN%)		17.3 ± 2.7		19.4 ± 2.8	**p<0.01[b]**
Energy (kcal)		2061 ± 549		2163 ± 570	**0.047[a]**
Energy (kcal/kg)		28.6 ± 10.2		31.1 ± 9.9	**0.020[a]**
Carbohydrates (g/d)		231.5 ± 76.4		231.1 ± 61.6	0.970[b]
Fat (g/d)		82.5 ± 24.2		86.2 ± 26.6	0.382[b]
Protein per meal					
Breakfast (g)	79	19.0 ± 8.2	66	23.9 ± 11.8	**0.018[a]**
During Morning (g)	56	6.5 ± 6.9	41	11.9 ± 8.9	**0.001[a]**
Lunch (g)	79	27.0 ± 10.9	65	29.4 ± 14.6	0.276[b]
During Afternoon (g)	57	9.0 ± 7.7	51	11.2 ± 7.2	0.127[b]
Dinner (g)	80	27.5 ± 10.8	67	32.4 ± 11.5	**0.009[a]**
During Evening (g)	32	10.8 ± 6.6	27	13.6 ± 7.7	0.133[b]
Reached 1.2 g/kg/d, n (%)		38 (47.5%)		53 (79.1%)	
Reached 1.5 g/kg/d, n (%)		16 (20.0%)		43 (64.2%)	

[a] Mann-Whitney U test used for skewed data

[b] Independent T-test used for normally distributed data

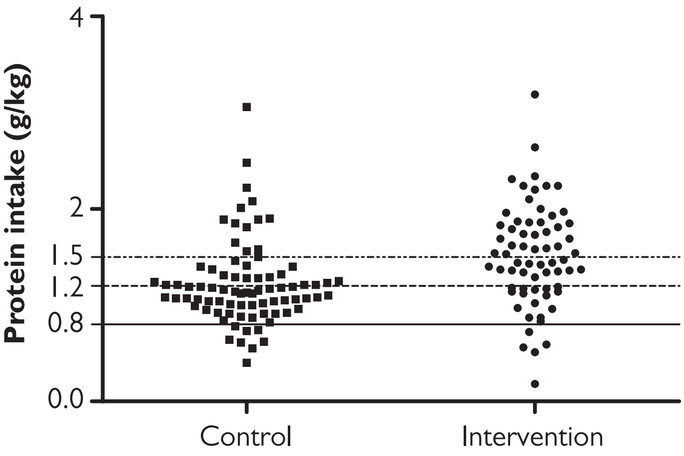


Figure 5.2: Column scatter of individual protein intake (g/kg) on day 4. The horizontal lines represent the current recommendation for adults (0.8 g/kg/d), and the new recommendation for older adults (1.2-1.5 g/kg/d).

When looking at protein intake per mealtime, we found significant differences between groups during breakfast, at the in between meal during the morning, and during dinner (Table 5.4 and Figure 5.3).

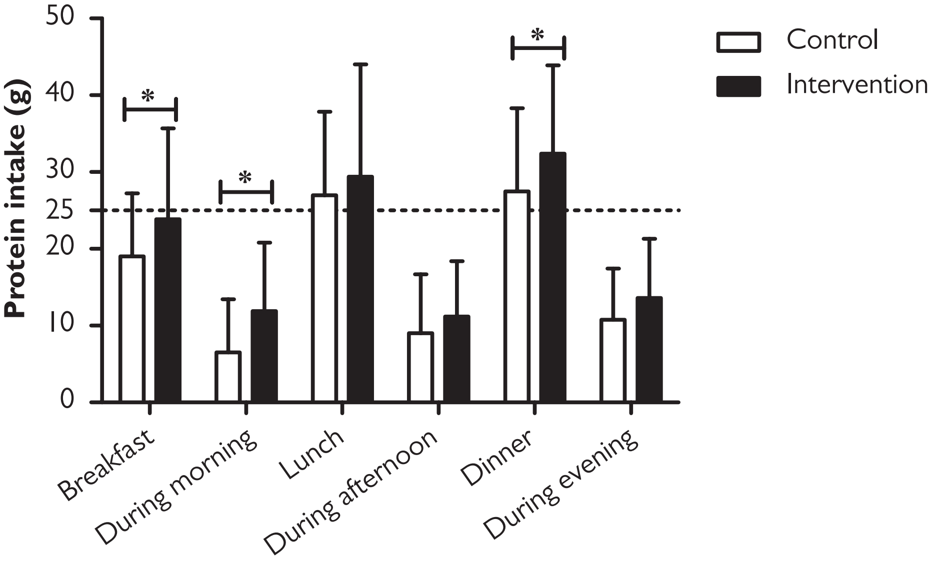


Figure 5.3: Protein supply per meal occasion (mean and SD are shown, * indicates a P<0.05 between groups). Horizontal line at 25 g represents the threshold that is suggested to be beneficial for muscle protein synthesis.[22]

5

Discussion

This randomized controlled trial showed that protein-enriched familiar foods increase the protein intake of hospitalized older adults even when compared to a group that already received an energy and protein rich hospital menu. As a result, 79% of the patients in the intervention group reached the recommended protein intake of 1.2 g/kg/d, compared to 48% of the patients in the control group.

The protein-enriched foods and drinks provided about a third (±31 g) of total protein intake in the intervention group. By providing a range of foods and drinks, we managed to increase protein intake during the whole day. A level of 25 grams per main meal is suggested to be beneficial for muscle protein synthesis.[22] For lunch and dinner this level was reached in both groups, but for breakfast only the intervention group came close with an intake of 24 grams. The large variety of protein-enriched foods and drinks shifted the food groups that provided most protein: the control group was mainly dependent on the natural protein-rich food groups dairy, meat, and cheese, while the intervention group received most protein from dairy (including protein-enriched dairy drinks), bread (including protein-enriched bread products), and non-dairy drinks (including protein-enriched fruit juices). Particularly the protein-enriched bread products and fruit juices were successfully implemented: these products contributed on average 12 and 7 grams of protein per patient per day.

We found a higher protein intake than that reported in a recent study by Stelten et al. [9] in which older patients received the standard hospital menu, with ad libitum regular bread and drinking yoghurt in the control group, which was replaced by ad libitum protein-enriched bread and drinking yoghurt in the intervention group. With just these two products, the intervention group reached a mean protein intake of 1.1 g/kg/d compared to 0.9 g/kg/d in the control group. However, only 36% of patients in the intervention group reached an intake of 1.2 g protein/kg/d.[9] In our study, this was 79%, which is most probably because of the large variety in our intervention products. Another difference between these studies was how the intervention products were offered: our participants had to actively order the products from an extensive menu, while participants in the other study received bread and drinking yoghurt from the researchers. This might have influenced the eating behavior of participants in two ways; participants may have forgotten to eat the offered products or may have felt obliged to eat more than they usually would. We can conclude from our study that the protein-enriched intervention products were chosen and consumed by participants, even when having freedom of choice from an extensive menu. The intake of protein-enriched products might have been even larger when we had actively offered them to the patients.

Protein-enrichment of familiar foods is just one nutritional strategy to increase protein intake of patients. A recent systematic review and meta-analyses of Bally et al. investigated the effects of several nutritional treatments on clinical outcomes and on protein and energy intake in patients at risk of malnutrition.[5] Most included studies investigated the effects of oral feeding strategies, mainly by using ONS, and often in combination with nutritional counselling. Overall, protein intake was increased by an average of 20 gram by the interventions. However, it should be noted that in these studies the mean protein intake in the control groups was only 46 g, which is almost half of the protein intake we found in our control group. Although ONS was an important intervention strategy in those reviewed studies, its use was negligible in our study; only 16 out of 147 patients consumed ONS. Therefore, only a small proportion of protein intake was a result of ONS consumption.

To estimate intake we used the MMS database with ordered foods and drinks. An advantage of using the MMS data is that we did not have to rely on a patient's memory as needed with a 24h recall. By using the MMS data, we could include patients with cognitive impairments, making our study group therefore a good reflection of the patients who are admitted to these wards. We knew from an earlier study that on a group level the MMS ordering data are a good proxy for intake in our hospitalized older patients (Chapter 3). One of the reasons is that with the At Your Request® meal service, food returns are lower than with the traditional 3-meals a day meal service that the hospital had before.[23] Although in our current study, the MMS data overestimated protein intake with 7 grams compared to 24h recalls, it is known that 24h recalls underestimate intake in older adults.[24] Patients did not consume much protein besides their ordered foods and drinks: on average only 1.7 gram per patient. Taking all this information into account, we are confident that the MMS ordering data are a good estimation of actual intake on a group level, and we did not adjust protein intake.

Whether the intake of 1.2-1.5 g/kg/d was needed for each of our patients can be discussed, because we did not measure nitrogen balance in our study patients. There is, however, growing evidence that older adults benefit from a higher protein intake. Therefore, two international expert groups recommended the intake of 1.2-1.5 g/kg/d for older adults suffering from diseases [7,8] and we chose to follow these new recommendations for protein intake.

For the implementation of protein-enriched products in hospitals it might be argued that these foods cost more than regular foods and drinks do. However, health economic studies have shown that using ONS saves costs per patient and decreases length of stay.[25] With the effects that we found in our study on protein intake, we believe that using protein-enriched products in a hospital could be cost-effective as well. Implementing these protein-enriched products in a hospital setting is easy; they can be used as replacement of regular foods and drinks or added to the menu options without needing to change the food service system or the amount of effort or time from the staff. By making protein-enriched foods and drinks the standard choice, more older patients will meet protein recommendations that will support them to recover from their illness.

Conclusion

This study shows that providing protein-enriched familiar foods and drinks, as replacement of regular products or as additions to the hospital menu, enables hospitalized older patients to better reach the recommended protein intake.

Acknowledgements

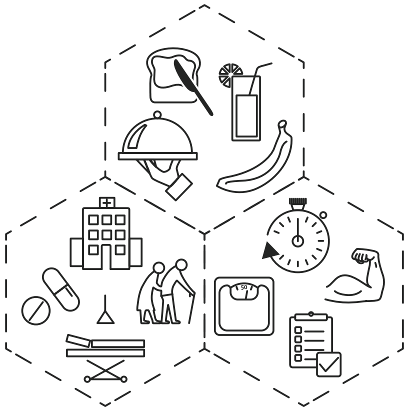
The authors thank the participants, and Anne Marsman, Kiki Spanjers, Astrid Doorduijn, Wout van Orten, and Renske Geers for their assistance during data collection and data cleaning.

5

References

1. Giesbers H. VA, Beer J. de,. Vergrijzing samengevat (Aging summarized). In: Volksgezondheid Toekomst Verkenning, Nationaal Kompas Volksgezondheid. . 2013. http://nationaalkompas.nl/bevolking/vergrijzing/vergrijzing-samengevat (accessed February 15, 2016.
2. Inzitari M, Doets E, Bartali B, et al. Nutrition in the age-related disablement process. J Nutr Health Aging 2011; 15(8): 599-604.
3. Health Council of the Netherlands. Undernutrition in the elderly. The Hague, 2011.
4. Norman K, Pichard C, Lochs H, Pirlich M. Prognostic impact of disease-related malnutrition. Clin Nutr 2008; 27(1): 5-15.
5. Bally MR, Blaser Yildirim PZ, Bounoure L, et al. Nutritional support and outcomes in malnourished medical inpatients: A systematic review and meta-analysis. JAMA Internal Medicine 2016; 176(1): 43-53.
6. Morley JE. Sarcopenia in the elderly. Fam Pract 2012; 29(suppl 1): i44-i8.
7. Deutz NEP, Bauer JM, Barazzoni R, et al. Protein intake and exercise for optimal muscle function with aging: Recommendations from the ESPEN Expert Group. Clin Nutr 2014; 33(6): 929-36.
8. Bauer J, Biolo G, Cederholm T, et al. Evidence-Based Recommendations for Optimal Dietary Protein Intake in Older People: A Position Paper From the PROT-AGE Study Group. J Am Med Dir Assoc 2013; 14(8): 542-59.
9. Stelten S, Dekker IM, Ronday EM, et al. Protein-enriched 'regular products' and their effect on protein intake in acute hospitalized older adults; a randomized controlled trial. Clin Nutr; 34(3): 409-14.
10. Neelemaat F, Lips P, Bosmans JE, Thijs A, Seidell JC, van Bokhorst-de van der Schueren MAE. Short-term oral nutritional intervention with protein and & vitamin D decreases falls in malnourished older adults. J Am Geriatr Soc 2012; 60(4): 691-9.
11. Nieuwenhuizen WF, Weenen H, Rigby P, Hetherington MM. Older adults and patients in need of nutritional support: review of current treatment options and factors influencing nutritional intake. Clin Nutr 2010; 29(2): 160-9.
12. Morley JE. Decreased food intake with aging. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences 2001; 56(suppl 2): 81-8.
13. Milne AC PJ, Vivanti A, Avenell A. . Protein and energy supplementation in elderly people at risk from malnutrition. Cochrane Database of Systematic Reviews 2009; (2).
14. Munk T, Beck AM, Holst M, et al. Positive effect of protein-supplemented hospital food on protein intake in patients at nutritional risk: a randomised controlled trial. J Hum Nutr Diet 2014; 27(2): 122-32.
15. Munk T, Seidelin W, Rosenbom E, et al. A 24-h a la carte food service as support for patients at nutritional risk: a pilot study. J Hum Nutr Diet 2013; 26(3): 268-75.
16. Beelen J, De Roos NM, De Groot LCPGM. Protein enrichment of familiar foods as an innovative strategy to increase protein intake in institutionalized elderly. J Nutr Health Aging 2016: 1-7.
17. Doorduijn AS, van Gameren Y, Vasse E, de Roos NM. At Your Request® room service dining improves patient satisfaction, maintains nutritional status, and offers opportunities to improve intake. Clin Nutr.
18. Dutch Health Care Inspectorate. 'Het resultaat telt 2012' (The result counts). Utrecht, 2014.
19. Dutch Health Care Inspectorate. 'Het resultaat telt 2013' (The result counts). Utrecht, 2015.
20. Weijs PJ, Sauerwein HP, Kondrup J. Protein recommendations in the ICU: g protein/kg body weight–which body weight for underweight and obese patients? Clin Nutr 2012; 31(5): 774-5.
21. RIVM. Dutch food composition dataset (NEVO). In: EuroFIR AISBL e-book Collection, editor. Brussel; 2013.
22. Paddon-Jones D, Rasmussen BB. Dietary protein recommendations and the prevention of sarcopenia: Protein, amino acid metabolism and therapy. Curr Opin Clin Nutr Metab Care 2009; 12(1): 86-90.
23. van Sas M. VK, Kooren N., van der Ploeg C., Herrewijn S., van den Assum S.,. Meer patiënten eten bord leeg (More patients completely eat their meals). Food Hospitality. 2013 August 2013:22-3.
24. Tooze JA, Vitolins MZ, Smith SL, et al. High Levels of Low Energy Reporting on 24-Hour Recalls and Three Questionnaires in an Elderly Low-Socioeconomic Status Population. The Journal of Nutrition 2007; 137(5): 1286-93.
25. Freijer K, Nuijten MJC. Analysis of the health economic impact of medical nutrition in the Netherlands. 2010; 64(10): 1229-34.

Chapter 6



Effects of a 12-week intervention with protein-enriched foods and drinks on protein intake and physical performance of older patients during the first 6 months after hospital release:
the randomized controlled Cater with Care® trial

Janne Beelen, Nicole M de Roos, Lisette CPGM de Groot

Submitted

Abstract

Objectives: During and after hospitalization older adults are recommended to consume 1.2 - 1.5 g of protein per kg body weight per day (g/kg/d) to improve recovery. We studied the effectiveness of protein-enriched familiar foods and drinks in reaching those goals.
Design, setting, participants, intervention: This randomized controlled trial followed 75 patients of ≥65 years (mean age: 76.8 ± 6.9 years) who took part in the hospital phase of this trial in their first 6 months after hospital release. During the 12-week intervention period at home, subjects in the intervention group could order protein-enriched foods and drinks, while the control group could order regular foods and drinks.
Measurements: Data were collected the day before discharge and 2, 6, 12, and 24 weeks after hospital release. Protein intake, indicators of physical performance, and body weight were measured.
Results: The intervention group had a higher protein intake during the 12-week intervention period compared to the control group ($P<0.01$): 112 ± 34 g/d (1.5 ± 0.6 g/kg/d) versus 78 ± 18 g per day (1.0 ± 0.4 g/kg/d). Energy intake did not differ between groups (2250 ± 531 kcal in intervention group, 2007 ± 493 kcal in controls, $P=0.070$). Physical performance, gait speed, chair rise time, body weight and nutritional status improved at week 12 compared to baseline (time effect $P<0.05$), but were not different between groups. Leg extension strength, hand grip strength, and independence in activities of daily living did not change up to 24 weeks.
Conclusion: Despite the lack of effect on physical recovery, protein-enriched foods and drinks enabled older adults to increase their protein intake, both during hospitalization as during the recovery phase at home.

Introduction

Hospitalization has a major impact on physical function of patients. Bed rest and physical inactivity during hospitalization accelerate the loss of muscle mass, strength, and function, which is more pronounced in older adults than in younger adults.[1] Moreover, older adults show a blunted response to dietary protein in protein synthesis after bed rest.[2,3] To improve the recovery of muscle strength and function, older adults may therefore need more dietary protein than the current recommended dietary allowance of 0.8 grams per kilogram body weight per day (g/kg/d).[3-5] Therefore, the PROT-AGE study group recently recommended a protein intake of 1.2 - 1.5 g/kg/d for older adult suffering from acute or chronic diseases.[4] However, protein intake of older adults during and after hospitalization is in general well below this level.[6-8] (& Chapter 3)

To overcome older adults' difficulties in consuming enough protein, enriching products they are used to consume within their daily menu might be an effective strategy. Two recent studies, one in a hospital and the other one in a rehabilitation center, found promising results for protein-enriched bread and drinking yoghurt.[7,9] Protein intake of the older participants increased in both studies as a result of using protein-enriched products, but the intervention periods were limited to a maximum of three weeks and only two products were provided. Therefore, a consortium of food companies, nutrition researchers, and health professionals developed a larger variety of protein-enriched familiar foods, tailored to the needs and preferences of older adults. These needs and preferences were based on interviews conducted with a group of older adults at risk of malnutrition. In the first phase of our current trial, we studied the effects of these products in hospitalized older adults and found that 79% of the intervention group reached a protein intake of at least 1.2 g/kg/d compared to 48% of the control group (Chapter 5). However, we do not know if this is maintained for a longer term at home, where recovery mainly takes place. Therefore, we continued the trial in a part of the patients at home after hospital discharge. In this home-phase study, our main outcome was not just an increased protein intake but the effect on physical performance as a measure of physical recovery after hospitalization. By increasing the protein intake of older patients with protein-enriched familiar foods and drinks during the first 12 weeks after hospitalization, we aimed to reach a protein intake of 1.2 - 1.5 g/kg/day and thereby improve physical performance in older patients in the first 6 months after hospital stay.

Methods

Study design

This study was designed as a randomized controlled trial (RCT) with two parallel intervention arms. The study started in the hospital for the duration of the patient's length of stay, and continued at home for 12 weeks. After another 12 weeks without intervention, a follow-up measurement was done (see Figure 6.1 for a schematic overview of the study design and a flowchart of subjects). Results of the hospital phase of this study focusing on protein intake have been published in a separate paper (Chapter 5). The study is registered on ClinicalTrials.gov (Identifier: NCT02213393). The Medical Ethics Research Committee of Wageningen University gave approval for this study.

Subjects

Recruitment took place between October 1, 2014 and April 1, 2015 in hospital Gelderse Vallei, Ede, the Netherlands. All patients of 65 years and older admitted to the departments of geriatrics/internal medicine or pulmonary medicine were screened for study eligibility. Firstly, exclusion criteria for the hospital phase were formulated, these have been published elsewhere (Chapter 5). Eligible patients were asked to participate in the hospital phase of the study within the first 2 days of their hospital stay and signed a written informed consent to gather information from their medical record. Secondly, participants in the hospital phase were screened for eligibility for the home phase of the study. Exclusion criteria for the home phase were: patient goes to a nursing home, rehabilitation center or hospice after hospital discharge; patient suffers from cognitive impairment (based on medical specialist's opinion) or is diagnosed with dementia; or is legally incapacitated. Eligible patients were visited by a research assistant as soon as possible after inclusion in the hospital phase to provide oral and written information about the home phase of the study. Patients who were willing to continue at home with the study signed a second informed consent.

Nutritional intervention

Subjects were randomly assigned to one of the two treatment groups. Randomization was done by an independent person by using a statistical program, with permuted blocks of size 4, stratified by gender and hospital department of admission.
The intervention in the hospital phase started within 2 days after hospital admission and continued until the end of a patient's hospital stay (more details on the hospital phase can be found in Chapter 5). The intervention was continued at home during 12 weeks, and subjects stayed in the assigned treatment group. Blinding was not possible as the product labels revealed whether products were protein-enriched. During the hospital phase, subjects received the intervention through the usual food service. Subjects in both groups were free to choose from their own menu what to order. Subjects received package deliveries at home twice a week during the first 12 weeks after hospital discharge. The packages were standardized during the first 2 weeks to familiarize the subjects with the entire assortment, from the third week onwards subjects were free to order whatever they wanted and as much they wanted through ordering forms. Subjects in the intervention group received the protein-enriched familiar products, while the control group received regular non-enriched variants of some of the intervention products. We decided

to offer the control group some protein-rich products such as dairy because we did not want to interfere with the standard advice to consume a protein-rich diet. To verify the protein content of the intervention products, chemical analyses were done (Kjeldahl method). All measured protein levels were within a margin of 5% of the protein content as provided by the manufacturers and shown in Table 6.1.

Table 6.1: Nutritional content of the intervention and control products (per portion).

		Control			Intervention		
Product group	**Product options**	**Portion size**	**Energy (kcal)**	**Protein (g)**	**Portion size**	**Energy (kcal)**	**Protein (g)**
Bread	"Light" bread †	35 g	86	3.2	35 g	93	5.8
	"Brown" bread	35 g	83	3.4	35 g	87	6.3
	"Dark" bread	35 g	82	3.9	35 g	87	5.8
	Raisin bread roll	50 g	134	4.2	50 g	141	5.8
	Brown bread roll	50 g	129	5.5	50 g	141	7.9
Cakes	Apple; cherry; or raspberry	-			65 g	295	9.9
Dairy desserts	Custard caramel; or macaroon-almond	-			150 g	212	9.9
	Custard vanilla	150 g	132	3.3	150 g	210	9.9
	Custard chocolate	150 g	143	3.9	-		
	Fresh cheese (quark) strawberry; or pear	-			150 g	173	12.6
	Yoghurt natural flavor	150 g	77	6.8	-		
	Yoghurt strawberry flavor	150 g	129	5.3	-		
Dairy drinks	Forest fruits; raspberry-strawberry; or tropical	-			150 ml	138	10.1
	Milk	250 ml	115	8.5	-		
	Milk banana; or strawberry- cherry	250 ml	110	5.3	-		
Fruit juices	Apple- strawberry; apple- blueberry; or orange	-			150 ml	82-88	10.1
	Forest fruit	-			200 ml	113	10.6
Ice cream	Forest fruits; red fruit	-			100 ml	144	10.0
Mashed potatoes		-			150 g	125	10.5

		Control			Intervention		
Product group	**Product options**	**Portion size**	**Energy (kcal)**	**Protein (g)**	**Portion size**	**Energy (kcal)**	**Protein (g)**
Meat	Veal meatball	-			80 g	242	21.2
	Veal sausage	-			80 g	190	18.3
	Veal blade	-			80 g	126	21.6
	Snack size meatballs, per 3	60 g	187	8.5	75 g	227	19.9
Porridge	Whole-wheat	-			150	106	11.1
Soups	Broccoli- cauliflower; mushroom; or tomato	-			150 ml	91-98	10.1

NB.: According to chemical analyses (with Kjeldahl-method): all measured protein levels were within 5% of the protein content as provided by the manufacturers.

† All intervention breads were whole-wheat, the control breads were regular white bread ("light"), regular wheat bread ("brown"), and regular whole-wheat bread ("dark").

Study outcomes

We defined two primary outcomes: protein intake and physical performance during the 12-week intervention period. Protein intake was measured at baseline (week 0), and at 2, 6, and 12 weeks after hospital discharge. As a baseline measurement of intake, the mean of the intake at the fourth day and the day before discharge in the hospital was used. Physical performance was measured at baseline (week 0), and at 2, 6, and 12 weeks after hospital discharge. Measurements from the day before discharge were used as a baseline of physical performance. For both protein intake and physical performance, a follow-up measurement was done at 24 weeks after hospital discharge.

Prior to the measurements, all assessors followed an extensive training on how to conduct the measurements. For all measurements standardized protocols were used, including a standardized protocol for encouraging the subjects to push (leg strength) or squeeze (hand grip strength) as hard as possible during the measurements. Moreover, dietary assessment was only done by trained dietitians.

Dietary assessment

During the home phase, protein intake was assessed using a 24h-recall combined with a dietary food record that was used as a memory aid. Participants were asked to record their food intake in household measures including all meals, snacks and beverages during one pre-specified day. During a home visit on the following day, the 24-h recall was carried out by trained dietitians in a face-to-face interview. During this interview the food records were checked for completeness and additional information was obtained about unclear items or amounts. In the hospital, we used the ordering data of patients at day 4 of hospitalization and the day before discharge. This method is on a group level a good proxy for protein intake in older patients admitted to these departments (Chapter 3 & 5).

The checked food records were entered into the food-calculation program Compl-eat (Department of Human Nutrition, Wageningen University, http://www.compleat.nl). Ordering data from the hospital phase were also entered into Compl-eat, with portion sizes based on the MMS database (in grams). Compl-eat was used to calculate energy (kcal/d) and macronutrient (grams/d) intake according to the Dutch food composition table 2013.[10] Protein intake was furthermore calculated for each subject in grams per kg bodyweight per day (g/kg/d). This was done for each measurement (week 0, 2, 6, 12 and 24). Average protein and energy intake was calculated for the whole 12-week intervention period as well. This was only done for subjects who completed at least 2 out of 3 measurements (week 2, 6, and 12).

The consumption of products was also reported in portions per patient on average during the 12-week intervention period. Furthermore, the contribution to protein intake (in %) of the intervention products in the intervention group was calculated for week 2, 6, and 12.

Physical performance outcomes

The primary outcome for physical recovery was measured with the Short Physical Performance Battery (SPPB). The SPPB consists of three components: balance, gait speed and chair rise time.[11] All three components of the SPPB were categorized into a five-level score, with 0 indicating the inability to perform a test and 4 indicating the highest level of performance. A total performance score between 0 and 12 was calculated by summing up the scores of the three tests.

Secondary outcomes for physical recovery were gait speed in seconds (measured within the SPPB), chair rise time in seconds (measured within the SPPB), leg extension strength, hand grip strength, body weight, nutritional status (Mini Nutritional Assessment; MNA), independence in activities of daily living (ADL), and physical activity (LAPAQ questionnaire).

To measure leg extension strength a hand-held dynamometer (MicroFET2) was used to measure isokinetic knee extensor strength (in Newton). Hand-held dynamometry has been shown to be a reliable method to measure leg strength in older adults.[12] Subjects were seated straight up with knees hanging in 90°, the hand-held dynamometer was placed at the front of the lower leg just above the ankle while the assessor was sitting firmly against a wall or supporting object. Subjects were instructed to push against the dynamometer by trying to straighten their knee. They were instructed to push to a maximum effort in two seconds and push as hard as possible until a stop sign was given (maximum of 10 seconds). Three consecutive measurements were recorded alternating both legs, making sure that each leg could rest one minute between measurements. The highest result of the three was used as maximum leg extension strength.

Hand grip strength was measured using a hand dynamometer (Lafayette Instrument Company).

Three consecutive measurements were done with alternating both hands, making sure that each leg could rest one minute between measurements. Subjects were instructed to squeeze as hard as possible until a stop sign was given. Attempts were recorded to the nearest 0.5 kg and the maximum strength effort was reported for the dominant hand.

Body weight was measured twice with a calibrated digital scale to 0.01 kg (SECA scale). When the two measurements were more than 0.1 kg apart, a third measurement was done. Mean body weight was calculated from all measurements. Only at baseline we could measure subjects, who could not stand on the scale, with a chair scale.

Nutritional status was measured with the MNA which is a validated nutrition screening and assessment tool that can identify patients of 65 years and older who are malnourished or at risk of malnutrition. The MNA includes in total 18 questions related to anthropometric measurements, mobility, dietary intake, and overall health.[13,14] The higher the total score, the better the nutritional status.

The Barthel Index (BI) was used to assess the level of independence in activities of daily living (ADL). This instrument contains ten items of which seven are related to basic ADL, and three items to mobility. The Dutch version of the questionnaire [15] was used. A summary score between 0 and 20 was calculated, with a higher score indicating more independence.

Physical activity was assessed with the LAPAQ questionnaire.[16] This questionnaire assesses the frequency and duration of physical activity in the previous two weeks. Daily activities included walking, cycling, gardening, and light and heavy household work, but also sport activities were included. Of each performed physical activity the frequency and duration was recorded in order to calculate physical activity in minutes per day.

All questionnaires (MNA, ADL, and LAPAQ) were filled out by the assessor in a face-to-face interview with the subject.

Characteristics

The following baseline characteristics were collected from the patient's medical record: age, gender, admission ward, medical diagnosis for admission, score on the Malnutrition Universal Screening Tool (MUST) at hospital admission, hemoglobin level (mmol/L) and vitamin D status (nmol/L). Hemoglobin and vitamin D levels were recorded to obtain an overall impression of health and nutritional status of the patient. Education level was asked from the patient. Height was measured with a stadiometer (SECA stadiometer) or when a participant could not stand up straight, the height recorded in the medical record was used. We checked whether the measured height differed from the height in the medical record for the subjects of whom we had both numbers (n=97). The medical record overestimated height by 2 cm on average, therefore final height was calculated by subtracting 2 cm from the medical record's height for those subjects without an actual measurement. BMI was calculated by dividing body weight by squared height. Length of hospital stay in days was recorded from the medical record after a patient was discharged.

Sample size

The sample size calculation was based on the primary outcome for physical recovery: the SPPB. Conform literature [17], we wanted to be able to detect a meaningful change of at least 1 point. According to the sample size calculation we needed 35 subjects per treatment group to detect this difference (using a power of 80%, α of 0.05, and an estimated standard deviation of 1.5 points). With 70 subjects, the minimally detectable change in protein intake was 0.24 g/kg/d. With an expected drop-out rate of 30%, we aimed to include 50 subjects per group.

Statistical analysis

To prevent mistakes in data entry, double data entry was done: two assistants individually entered data into a dataset, and when finished the 2 datasets were compared in SPSS by a third person, after which unmatched values were checked and corrected. Statistical analysis was done by the intention-to-treat principle, considering that our intervention was not strictly defined in terms of obliged consumption; subjects were free to order and consume whatever and how much they wanted. IBM SPSS Statistics Version 22 was used and analyses were done conform a predefined analysis plan. Statistical significance was set at $P<0.05$. Descriptive statistics were performed to describe baseline characteristics and are presented as mean ± standard deviation. Independent T-tests were done to test whether the two groups were still comparable at baseline, because randomization took place at the start of the hospital phase and only half of the subjects in the hospital phase continued in the home phase. The differences in dietary intake between the two intervention groups were analyzed by using an independent T-test. Differences in physical performance outcomes between groups over time were analyzed with linear mixed models, with time, group, and their interaction as fixed factors and subjects were defined as random factors in the model. For all outcomes a random intercept model was used, with appropriate covariates and covariance structures. The appropriate covariates and covariance structures were chosen by using a top-down model fitting procedure. These differ between the different outcome variables. Linear mixed models estimated means and standard errors, therefore the data on these outcomes are presented as mean ± SEM. Excluding subjects who withdrew from the study within 2 weeks did not affect the results, and therefore all recorded measurements were included in the linear mixed model analysis.

Results:

Subjects

Between October 2014 and April 2015, 860 patients were screened for eligibility and 159 patients of these gave consent to participate in the hospital phase of the study (exclusion reasons for the hospital phase are published elsewhere (Chapter 5). From these 159 subjects, 84 did not continue in the home phase because of the following reasons: refusal to participate (n=33); transferred to other specialism or hospital (n=22); cognitive impairments (n=13); not living independent (n=12); died during hospitalization or treatment plan changed into palliative care (n=4). In total, 75 subjects gave consent to continue participation in the home phase of the study (39 in the control group and 36 in the intervention group). During the first 2 weeks at home, 7 subjects of the control group and 6 subjects from the intervention group withdrew from the study. Between the measurements of week 2 and 12, another 3 in the control group and 3 in the intervention group withdrew from participation. During the follow-up phase 3 subjects in each group dropped-out. Figure 6.1 shows the study design and flowchart of subjects with reasons for withdrawal.

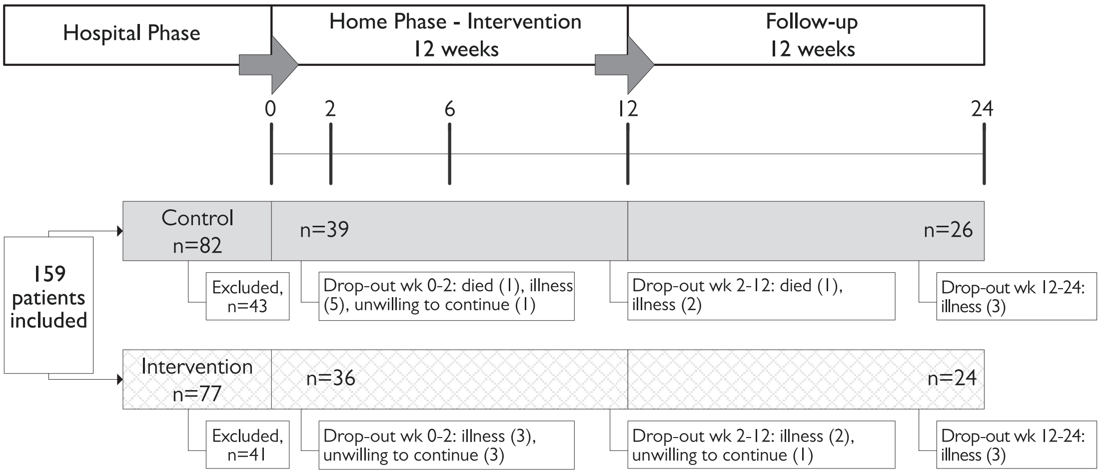


Figure 6.1: Study design and flowchart of participants. Week 0, 2, 6, 12, and 24 indicate measurement moments, with 0 as day before discharge. Reasons for drop-outs (number of subjects) are given for specific periods.

Although only half of the subjects from the hospital phase continued in the home phase, characteristics were comparable in both groups (P>0.05). At baseline, the study population had a mean age of 76.8 ± 6.9 years, and were mostly admitted to the pulmonary medicine ward for lung disease related reasons for hospital admission (Table 6.2). Mean length of stay was 8 days in the control group and 9 days in the intervention group. The majority of subjects had a low risk of malnutrition according to the MUST screening. Education level was low in most patients in both groups.

Table 6.2: Baseline characteristics

	Control (n=39)	Intervention (n=36)	P value
Age (years), mean± SD	77.2 ± 7.2	76.5 ± 6.7	0.662
Female, n (%)	22 (56.4)	20 (55.6)	
Male, n (%)	27 (43.6)	16 (44.4)	
Height (m), mean± SD	1.66 ± 0.08	1.67 ± 0.08	0.816
Body weight (kg), mean± SD	78.4 ± 19.0	74.5 ± 15.6	0.331
BMI (kg/m²), mean± SD	28.2 ± 5.6	26.9 ± 6.1	0.360
Vitamin D (nmol/L), mean ± SD *	50.4 ± 30.1	68.1 ± 31.0	0.109
Hemoglobin (mmol/L), mean ± SD	8.5 ± 1.3	8.3 ± 1.3	0.385
CRP (mg/L), mean± SD	49.8 ± 71.2	42.5 ± 57.6	0.523 †
Length of Stay (d), mean± SD	8.0 ± 2.5	8.8 ± 4.1	0.864 †
Admission Ward, n (%)			
Geriatric and internal medicine	11 (28.2)	9 (25.0)	
Pulmonary medicine	28 (71.8)	27 (75.0)	
Medical diagnosis for admission, n (%)			
Exacerbation COPD, Asthma	16 (41.0)	13 (36.1)	
Lung infection, Lung inflammation	7 (17.9)	4 (11.1)	
Other pulmonary diseases (e.g. Pulmonary embolism, Pneumosepsis, Pneumothorax)	7 (17.9)	12 (33.3)	
Other inflammation or infection (not lung)	2 (5.1)	1 (2.8)	
Malaise	3 (7.7)	2 (5.6)	
Other	4 (10.3)	4 (11.1)	

6

	Control (n=39)		Intervention (n=36)	
MUST score, n (%)				
MUST 0	33	(84.6)	26	(72.2)
MUST 1	2	(5.1)	3	(8.3)
MUST ≥2	4	(10.3)	7	(19.4)
Education Level, n (%) ‡				
Low	30	(76.9)	24	(66.7)
Middle	3	(7.7)	8	(22.2)
High	3	(7.7)	2	(5.6)
Unknown	3	(7.7)	2	(5.6)

* measured in 15 control patients and 18 intervention patients.

† Mann-Whitney U test used for skewed data.

‡ Education level was based on the highest level of education completed and divided in three categories: low (no education, primary or lower secondary school), middle (higher secondary school or intermediate vocational school), and high (higher professional education or university level).

Protein intake

In the intervention group, intervention products contributed substantially to total protein intake during the 12-week intervention period: 61% at the measurement of week 2, 56% at week 6, and 49% at week 12. Dominant protein sources for the intervention group were dairy products, while the control group received most protein from meat products (Table 6.3). A large difference between groups was found in protein provided by non-dairy drinks: the intervention group received 11 g protein from (mainly protein-enriched) drinks, while the control group only received 2 g protein from drinks.

Table 6.3: Protein intake from food groups, including intervention products: consumed number of portions and the amount of protein (g) (based on the mean consumption of the 3 measurements at home; week 2, 6 and 12).

	Control		**Intervention**	
Product groups / Products	**Portions (n)**	**Protein (g)**	**Portions (n)**	**Protein (g)**
Bread	4.2	13.2	3.6	17.2
of which protein-enriched bread products	-	-	2.4	14.5
Cakes and pastry	0.9	1.6	1.2	3.9
of which protein-enriched cakes	-	-	0.3	2.6
Dairy	4.3	17.0	4.4	28.6
of which protein-enriched dairy drinks, dairy desserts and ice cream	-	-	1.9	20.8
Drinks (non-dairy)	6.1	1.8	6.5	10.9
of which protein-enriched fruit juices	-	-	0.9	9.6
Meat	1.9	22.0	1.6	20.5
of which veal products	-	-	0.4	7.7
Potatoes, cereals, pasta, rice	1.0	3.0	1.3	7.1
of which protein-enriched mashed potatoes	-	-	<0.1	0.3
of which protein-enriched porridge	-	-	0.3	3.7
Soups	0.3	1.3	0.7	6.7
of which protein-enriched soups	-	-	0.5	5.0
Cheese	1.2	7.3	1.1	5.5
Eggs	0.2	1.6	0.2	1.3
Fish	<0.1	0.6	<0.1	1.1
Oral Nutritional Supplements (ONS)	0.1	1.1	0.3	3.5

Portion sizes are the same for both groups.

The use of the protein-enriched intervention products led to an increased mean protein intake in the intervention group compared to the control group: 112 ± 34 compared to 78 ± 18 g per day ($P<0.01$) which corresponds to a mean protein intake of 1.5 ± 0.6 g/kg/d versus 1.0 ± 0.4 g/kg/d ($P<0.01$). Energy intake did not differ significantly between groups ($P=0.070$). The higher mean protein intake in the intervention group resulted in more subjects reaching the recommended protein intake of 1.2 g/kg/d: 72% of the intervention group compared to 31% in the control group (Table 6.4).

Table 6.4: Mean protein and energy intake during home phase intervention (week 2, 6, 12; only calculated when a subject had completed at least 2 out of 3 measurements). Data shown as mean ± SD. Number of subjects that reached a protein intake of 1.2 g/kg/d (n, %).

	Control	**Intervention**	**P value**
Protein (g/d)	78 ± 18	112 ± 34	<0.01 *
Protein (g/kg/d)	1.0 ± 0.4	1.5 ± 0.6	<0.01 *
Energy (kcal/d)	2007 ± 493	2250 ± 531	0.070
Reached 1.2 g/kg/d, n (%) †	10/32 (31.3%)	21/29 (72.4%)	

* Indicates significant difference between groups (tested with Independent T test).

† Based on the mean intake and therefore includes only people who completed at least 2 out of 3 measurements.

Furthermore, the intervention group reached a higher protein intake than the control group did during each meal occasion. Both lunch and dinner provided at least 25 g protein, while breakfast remained below this level in both groups. All 3 snack occasions were significantly higher in protein in the intervention group than in the control group (Figure 6.2).

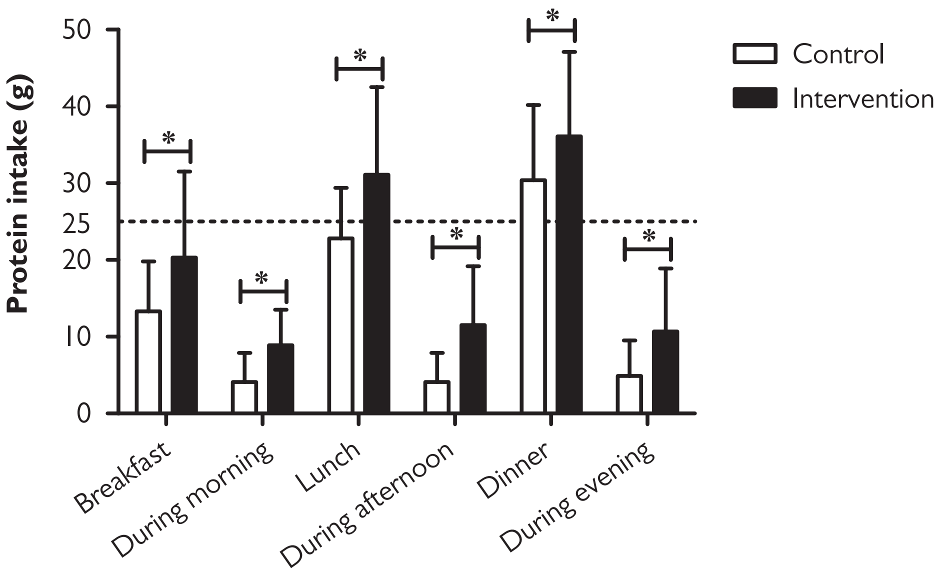


Figure 6.2: Protein intake per meal occasion on average intake during the home phase. Means ± SD shown, * indicates significant difference between groups (P<0.05).

Physical performance

Physical performance outcomes are shown in Table 6.5. Leg extension strength is only reported for the right leg; results found in the left and right leg were similar. None of the outcomes showed a significant group effect, or interaction of group x time effect. In both groups time effects were found for physical performance (SPPB), gait speed, chair rise time, body weight, nutritional status (MNA), and physical activity (LAPAQ). Leg extension strength, hand grip strength, and independence in activities of daily living (ADL) did not change over time. Data shown in Table 6.5 were derived from mixed models without the measurement of week 24, because our main interest was to measure the effect of the protein-enriched products during the 12 week intervention period. Including the follow-up measurements of week 24 did not change the estimated means and did not alter significance of time, group or interaction effects. Furthermore, these follow-up measurements at week 24 did not show significant differences between groups.

Post-hoc analysis

Because not all subjects in the intervention group reached the desired protein intake of 1.2 g/kg/d and some subjects in the control group did, we performed an additional stratified analysis for SPPB score by protein intake (mean protein intake below or above 1.2 g/kg/d during the 12-week intervention period). Figure 6.3 shows the results of this analysis. The group with an intake above 1.2 g/kg/d had a higher score at each measurement. Furthermore, SPPB improved significantly over time in both groups, but the group with a higher protein intake recovered faster in SPPB score (week 6 was already different from baseline) than the group with a lower intake did (week 12 was different from baseline). There were, however, no interaction effects of group x time found.

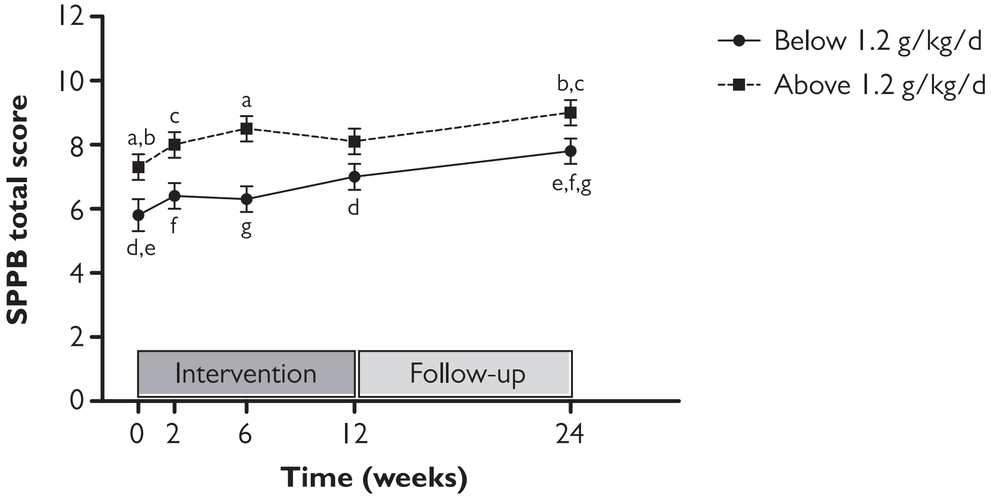


Figure 6.3: Post-hoc analysis on physical performance (SPPB) in groups based on mean protein intake during the 12 week home phase; subjects with a mean protein intake of below 1.2 g/kg/d, and subjects with a mean protein intake of above 1.2 g/kg/d. Data represents means ± SEM. There were significant effects of time (P<0.01) and group (P=0.003), but no group x time interaction effect (P>0.05). The same letters on 2 time points indicate a significant difference between these 2 time points within a group (e.g. in the group with an intake above 1.2 g/kg/d, week 0 and 6 are significantly different).

6

Table 6.5: Physical recovery outcomes at baseline (0 = day before discharge from hospital), after 2, 6 and 12 weeks in the control and intervention group. Data represents means ± SEM. Intention to treat analyses were done with a linear mixed model (no subjects were excluded from the analyses).

	Control				**Intervention**			
	0	**2**	**6**	**12**	**0**	**2**	**6**	**12**
SPPB total	6.0 ± 0.4	6.8 ± 0.4	**7.1 ± 0.4***	**7.5 ± 0.5***	6.8 ± 0.4	7.2 ± 0.5	7.3 ± 0.4	7.3 ± 0.5
Gait speed (sec)	7.3 ± 0.7	6.9 ± 0.5	6.5 ± 0.5	6.2 ± 0.5	8.5 ± 0.7	6.9 ± 0.5	6.7 ± 0.5	**6.6 ± 0.5***
Chair rise (sec)	31.8 ± 3.1	**23.0 ± 3.1***	**22.3 ± 3.0***	**19.3 ± 3.1***	25.0 ± 3.2	21.8 ± 3.1	20.1 ± 3.2	20.0 ± 3.3
Leg extension strength (newton)	218.1 ± 6.9	222.3 ± 7.5	218.0 ± 7.4	218.9 ± 7.5	226.9 ± 7.0	240.0 ± 7.7	230.5 ± 7.7	230.4 ± 8.1
Hand grip strength (kg)	25.5 ± 1.5	24.6 ± 1.3	25.3 ± 1.4	24.9 ± 1.6	27.1 ± 1.6	25.3 ± 1.4	25.4 ± 1.4	26.4 ± 1.7
Body weight (kg)	77.8 ± 2.8	77.9 ± 2.8	**78.8 ± 2.8****	78.7 ± 2.8	75.2 ± 2.9	75.9 ± 2.9	76.0 ± 2.9	75.7 ± 3.0
MNA (points)	22.5 ± 0.5	**24.4 ± 0.6***	**24.8 ± 0.6***	**25.2 ± 0.6***	22.6 ± 0.5	23.6 ± 0.6	**24.4 ± 0.6***	**25.1 ± 0.6***
ADL (points)	17.2 ± 0.5	17.5 ± 0.5	17.0 ± 0.5	16.8 ± 0.5	17.1 ± 0.5	17.2 ± 0.5	17.4 ± 0.5	17.0 ± 0.5
Physical activity (min/d)	31.6 ± 9.7	**71.8 ± 10.4***	**78.1 ± 10.4***	**85.1 ± 10.6***	39.6 ± 9.9	**79.2 ± 10.4***	**84.5 ± 10.4***	**84.5 ± 10.7***

* Indicates a significant time effect ($P<0.05$) compared to baseline within a group. ** Indicates a significant time effect ($P<0.05$) compared to week 2 within the control group. No group or interaction of group and time effects were found ($P>0.05$).

Discussion

Protein-enriched foods and drinks were successfully implemented in the menu of older adults. Although these foods and drinks increased protein intake, this did not result in a greater improvement in physical performance.

We were able to achieve a high protein intake for as long as 12 weeks which was much longer than in two previous studies of 3 days and 3 weeks.[7,9] Such long-term adherence may be the result of the large assortment of protein-enriched familiar foods and drinks. Protein-enriched dairy drinks, bread, and soups were major protein contributors, but also alternatives as fruit juices and porridge contributed a substantial amount of protein. By only using protein-enriched familiar foods and drinks we found a higher protein intake compared to a study that combined dietetic treatment and oral nutritional supplements (ONS) for 12 weeks after discharge among undernourished older adults.[6] We believe that the protein-enriched familiar foods and drinks can even be used on a longer term than 12 weeks, because the amount of these products ordered remained stable over time. When the products would have been available for a longer period, we still may have found a difference between groups after 6 months which was currently not present anymore.

In contrast to some other studies that reported positive effects of protein supplementation on physical performance [18,19], we found no effect on the physical performance outcomes. This may be due to two reasons: the high protein intake in the control group and the lack of physical activity in our study population. These two explanations could also be associated to the fact that a large part of our subjects were Chronic Obstructive Pulmonary Disease (COPD) patients. COPD patients are recommended to increase their energy and protein intake because they would benefit from a high intake due to chronic inflammation.[3] However, even the high protein intake of 1.5 g/kg/d of our intervention group may have been too low for these patients to improve physical performance. Furthermore, the condition of a COPD patient (shortness of breath, exhaustion) usually prevents an active lifestyle [20,21] which was also seen in our study.

The rather high protein intake of the control group is probably a joint result of the following two factors: first, the participating hospital offers protein- and energy-rich menus to older patients in the participating departments, and all discharged patients receive information about the importance of protein during the recovery phase after hospitalization; second, the control group received dairy products in their packages during the home phase. This was done because we thought it would be unethical to give them products low in protein while they were given the advice to choose a protein-rich menu. Providing these packages indeed had an impact on their protein intake: at the follow-up measurement of week 24, the protein intake of both groups was much lower compared to the first 12 weeks (see supplementary data). This suggests that the participants were not able to maintain a high protein intake themselves, and that the free delivery service of the packages was therefore also of great importance during the intervention period.

The post-hoc analysis showed that the physical performance of subjects with an average intake of at least 1.2 g/kg/d increased faster than of the subjects who had a lower intake than 1.2 g/kg/d. Furthermore, the subjects who reached the intake of 1.2 g/kg/d had a higher SPPB score at each time point. However, the interaction effect was not statistically significant, meaning that a higher protein intake did not change physical performance to a greater extent overtime. We speculated that this may be due to the inactive study population. To further investigate the effects of the activity level of the study population, we did another additional post-hoc analysis including only subjects who performed sports activities (data not shown). This had no effect on the results: differences in SPPB score remained the same between the groups. The performed sports may have been too low in intensity or not focused on resistance-type exercise. Especially resistance-type exercise is effective in increasing physical performance and strength in older adults.[22] If we could have combined the nutritional intervention of our study with a resistance-type exercise program, we might have found more positive results on the physical performance outcomes in our study. However, this was not possible in our recent study due to practical and financial constraints. These factors also hindered continuing the recruitment to reach the desired sample size; we wanted to recruit 50 patients in each to group to end up with 35 per group. However, within the recruitment period we had only 75 patients who continued the study at home after hospital release. But even when we would have included enough patients, it seems unlikely that we would have been able to detect a statistical significant difference; the standard deviation we found was larger than what we used in the sample size calculation.
It could be argued that an intervention period of 12 weeks is not long enough. Tieland et al. found a result after 24 weeks of protein supplementation [18], while Kim et al. found a positive result after 12 weeks of protein supplementation.[19] In our results, we saw improvements in physical performance outcomes especially within the first six weeks of the intervention, but after that values plateaued (both in the original analyses as well as in the post-hoc analyses). Therefore, we do not think a longer intervention period would have yielded different results.
We chose to stay close to reality, with a free-choice intervention instead of giving strict guidelines on what and when to eat. Although our participants had a free choice in what to consume and how much, the variety of products helped them to maintain a higher protein intake on a longer term. Some participants in the intervention group did not reach an average protein intake of 1.2 g/kg/d for 12 weeks, so for some people other strategies could be more beneficial.
In conclusion, protein-enriched familiar foods and drinks enabled older adults to increase their protein intake, both during hospitalization as on a longer term during a recovery phase at home. Although the data do not support an expected improvement in physical recovery in the first 6 months after hospital release we do not rule out a beneficial role of these protein-enriched products in combination with exercise in older adults that normally have low protein intakes.

Acknowledgements

The authors thank the participants, staff of hospital Gelderse Vallei, and all research assistants for their assistance during data collection and data cleaning.

6

References

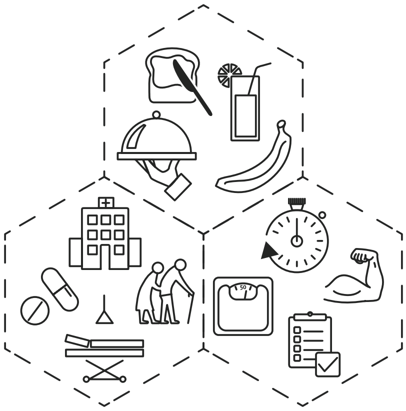
1. English KL, Paddon-Jones D. Protecting muscle mass and function in older adults during bed rest. Curr Opin Clin Nutr Metab Care 2010; 13(1): 34.
2. Tanner RE, Brunker LB, Agergaard J, et al. Age-related differences in lean mass, protein synthesis and skeletal muscle markers of proteolysis after bed rest and exercise rehabilitation. The Journal of Physiology 2015; 593(18): 4259-73.
3. Deutz NEP, Bauer JM, Barazzoni R, et al. Protein intake and exercise for optimal muscle function with aging: Recommendations from the ESPEN Expert Group. Clin Nutr 2014; 33(6): 929-36.
4. Bauer J, Biolo G, Cederholm T, et al. Evidence-Based Recommendations for Optimal Dietary Protein Intake in Older People: A Position Paper From the PROT-AGE Study Group. J Am Med Dir Assoc 2013; 14(8): 542-59.
5. Wolfe RR, Miller SL, Miller KB. Optimal protein intake in the elderly. Clin Nutr 2008; 27(5): 675-84.
6. Neelemaat F, Lips P, Bosmans JE, Thijs A, Seidell JC, van Bokhorst-de van der Schueren MAE. Short-term oral nutritional intervention with protein and & vitamin D decreases falls in malnourished older adults. J Am Geriatr Soc 2012; 60(4): 691-9.
7. Stelten S, Dekker IM, Ronday EM, et al. Protein-enriched 'regular products' and their effect on protein intake in acute hospitalized older adults; a randomized controlled trial. Clin Nutr; 34(3): 409-14.
8. Bally MR, Blaser Yildirim PZ, Bounoure L, et al. Nutritional support and outcomes in malnourished medical inpatients: A systematic review and meta-analysis. JAMA Internal Medicine 2016; 176(1): 43-53.
9. van Til A, Naumann E, Cox-Claessens I, Kremer S, Boelsma E, de van der Schueren MA. Effects of the daily consumption of protein enriched bread and protein enriched drinking yoghurt on the total protein intake in older adults in a rehabilitation centre: A single blind randomised controlled trial. J Nutr Health Aging 2014; 19(5): 525-30.
10. RIVM. Dutch food composition dataset (NEVO). In: EuroFIR AISBL e-book Collection, editor. Brussel; 2013.
11. Guralnik JM, Simonsick EM, Ferrucci L, et al. A Short Physical Performance Battery Assessing Lower Extremity Function: Association With Self-Reported Disability and Prediction of Mortality and Nursing Home Admission. J Gerontol 1994; 49(2): M85-M94.
12. Schaubert KL, Bohannon RW. Reliability and validity of three strength measures obtained from community-dwelling elderly persons. The Journal of Strength & Conditioning Research 2005; 19(3): 717-20.
13. Vellas B, Villars H, Abellan G, et al. Overview of the MNA® - Its history and challenges. Journal of Nutrition Health and Aging 2006; 10(6): 456.
14. Néstle Nutrition Institution. MNA® Mini Nutritional Assessment. http://www.mna-elderly.com (accessed March 23rd, 2014.
15. Post M.W.M. vAFWA, van Dijk A.J., Schrijvers A.J.P.,. Nederlandse interviewversie van de Barthel-index onderzocht bij dwarslaesiepatiënten. Ned Tijdschr Geneeskd 1995; 139: 1375-80.
16. Stel VS, Smit JH, Pluijm SMF, Visser M, Deeg DJH, Lips P. Comparison of the LASA Physical Activity Questionnaire with a 7-day diary and pedometer. J Clin Epidemiol 2004; 57(3): 252-8.
17. Perera S, Mody SH, Woodman RC, Studenski SA. Meaningful change and responsiveness in common physical performance measures in older adults. J Am Geriatr Soc 2006; 54(5): 743-9.
18. Tieland M, van de Rest O, Dirks ML, et al. Protein Supplementation Improves Physical Performance in Frail Elderly People: A Randomized, Double-Blind, Placebo-Controlled Trial. J Am Med Dir Assoc 2012; 13(8): 720-6.
19. Kim C-O, Lee K-R. Preventive Effect of Protein-Energy Supplementation on the Functional Decline of Frail Older Adults With Low Socioeconomic Status: A Community-Based Randomized Controlled Study. The Journals of Gerontology Series A: Biological Sciences and Medical Sciences 2013; 68(3): 309-16.
20. de Blok BMJ, de Greef MHG, ten Hacken NHT, Sprenger SR, Postema K, Wempe JB. The effects of a lifestyle physical activity counseling program with feedback of a pedometer during pulmonary rehabilitation in patients with COPD: A pilot study. Patient Educ Couns 2006; 61(1): 48-55.
21. Pitta F, Troosters T, Spruit MA, Probst VS, Decramer M, Gosselink R. Characteristics of Physical Activities in Daily Life in Chronic Obstructive Pulmonary Disease. Am J Respir Crit Care Med 2005; 171(9): 972-7.
22. Tieland M, Dirks ML, van der Zwaluw N, et al. Protein Supplementation Increases Muscle Mass Gain During Prolonged Resistance-Type Exercise Training in Frail Elderly People: A Randomized, Double-Blind, Placebo-Controlled Trial. J Am Med Dir Assoc 2012.

Additional Data

Table A1: Supplementary data: Energy and macronutrient intake, and protein intake per meal occasion, at baseline (0 = day before discharge from hospital), after 2, 6 and 12 weeks in the control and intervention group (shown as mean ± SD).

	Control					Intervention				
	0 (n=39)	**2 (n=30)**	**6 (n=30)**	**12 (n=29)**	**24 (n=26)**	**0 (n=36)**	**2 (n=26)**	**6 (n=28)**	**12 (n=26)**	**24 (n=23)**
Protein (g)	84±21	79±21	77±19	81±26	68±24	105±37	119±41	113±46	105±38	81±35
Protein (g/kg)	1.1±0.3	1.1±0.4	1.0±0.4	1.1±0.4	0.9±0.3	1.4±0.5	1.6±0.7	1.6±0.8	1.4±0.7	1.1±0.6
Protein (EN%)	17±2.6	16±2.4	16±2.9	17±4.2	16±3.6	19±2.5	20±3.5	20±4.5	19±4.7	15±3.3
Energy (kcal)	1986±433	2033±529	1983±534	1998±624	1752±555	2219±664	2367±685	2197±702	2181±581	2080±698
Carbohydrates (g)	218±63	237±77	233±73	224±75	205±73	240±71	271±78	245±82	234±68	224±74
Fat (g)	81±20	78±26	75±24	77±36	65±26	88±29	80±30	77±31	84±33	86±41
Protein per meal										
Breakfast (g)	17±7	14±8	14±6	12±9	10±7	25±10	20±12	21±16	19±12	12±7
During Morning (g)	5±5	4±4	4±3	5±5	4±3	10±8	10±9	7±8	9±10	3±3
Lunch (g)	26±9	21±7	23±9	24±12	21±10	30±12	34±14	32±17	28±12	21±10
During Afternoon (g)	9±7	5±7	4±4	4±5	3±6	11±7	16±11	11±10	9±8	6±10
Dinner (g)	29±8	31±14	30±12	32±20	28±16	32±10	34±14	41±17	34±15	31±21
During Evening (g)	8±6	5±6	3±3	6±8	3±4	13±7	11±10	12±10	10±11	8±8

Chapter 7



General discussion

Main findings

The overall aim of this thesis was to evaluate the impact of protein-enriched foods and drinks on protein intake and performance of older adults prone to develop undernutrition. Older adults are unaware of the risks and consequences of undernutrition. This hinders early diagnosis and current dietetic treatment which includes the advice to eat protein-rich foods. The effectiveness of dietetic treatment could benefit from the introduction of novel protein-enriched foods and drinks (**chapter 2**). Even if older patients are offered a menu that contains protein-rich options, their protein intakes are still not adequate (**chapter 3**), suggesting that protein-enrichment of products that are not naturally rich in protein is a necessity. The value of these products in improving protein intake was demonstrated in two intervention studies in which protein-enriched Cater with Care® products were added to the menu of institutionalized and hospitalized older adults (**chapter 4, 5**). This result was maintained in a 12-week intervention period at home. However, despite the successful improvement of protein intake, we found no added value on physical performance in the first 6 months after hospitalization (**chapter 6**).

Trajectory towards the effectiveness study in clinical practice

In this thesis we worked towards a carefully designed effectiveness study in clinical practice within the context of the Cater with Care® project. This project was a collaboration between the university, care organizations, and partners from the food industry. The industrial partners developed the products in collaboration with NIZO: Carezzo Nutrition developed bakery products, and fresh juices and soups; The Kraft Heinz Company focused on long shelf-life and convenience foods; and SPK produced veal meat. Products were adjusted with input from the Cater with Care® studies addressing preferences of older adults (step 1), their habitual intakes (step 2), and appreciation of the newly developed protein-enriched foods (step 3).

Step 1. Interviews with dietitians and older adults: exploring preferences regarding protein-enriched products

From interviews with dietitians and older adults at risk of undernutrition, we learned that the products for the effectiveness study should be enriched with protein, should match eating habits of Dutch older adults, and should come in small portions. Furthermore, products should be easy to prepare, to open, and to consume. Therefore, we only developed products that were either ready to eat (e.g. bread, fruit juices, dairy drinks), or that needed only to be heated (soups and meat products), or mixed with hot water (instant mashed potatoes and porridge). The effectiveness study confirmed this approach was successful: the products were easily incorporated into the older adults' eating patterns. Unfortunately, development of innovative easy-to-open packaging did not fit into the project's time window, but this should be addressed when commercializing these products.

Step 2. Observational study: current intake and product choices of target population

Furthermore, we gained insights in food choices of older patients by conducting an observational study in the hospital. At that point, we were still exploring options for the most appropriate target group for the effectiveness study. The observation that protein intakes were even lower in patients with a low risk of undernutrition than those with increased risk was directive for the selection of our target population for the effectiveness study: all older patients disregarding their undernutrition risk. This deliberate choice does not match recommendations of the Health Council [1], that called for studies with undernourished patients, but is justified by our own observations in clinical practice.

Step 3. Pilot testing the first developed products in institutionalized elderly

A limited assortment of protein-enriched products was offered to institutionalized elderly to gain product feedback and to test the feasibility of an effectiveness study. With their feedback, the assortment was improved. Especially snack products that were too hard to chew or too satiating were replaced by softer products in smaller portions. The final assortment contained staple foods such as bread and mashed potatoes but also a variety of drinks and snacks. However, we lacked desserts so we bought protein-enriched dairy desserts from a company outside the consortium. Veal products were not protein-enriched, but by making easy-to-chew products (e.g. meat balls, sausages) they were appropriate for elderly. Importantly, the pilot study showed that the protein-enriched foods and drinks did not lead to compensation of other protein-rich foods.

Furthermore, insights were gained about the feasibility of the effectiveness study. Before the pilot, we thought institutionalized elderly could be an appropriate target group, considering their low intake.[2,3] However, willingness to participate was low, and their physical performance was low and in a 'steady-state', suggesting that it would be hard to find an effect of extra protein. Instead, we presumed that an increased protein intake would have a larger effect in patients who were recovering from hospitalization, and who would be motivated to recover to remain independent.

Effectiveness study in practice

The product choices and chosen study population were appropriate for the effectiveness study but the wider application and relevance will be discussed here.

Clinical study population: generalizability

The Health Council stated in their report that a study population should be "as homogenous as possible in terms of illness, care setting, and psychosocial characteristics (loneliness, mourning, and depression)".[1] In terms of illness and care setting, a homogenous group was selected for the effectiveness study: non-surgical older patients from the departments of geriatric medicine and pulmonary medicine. We did not use psychosocial characteristics as exclusion criteria because this would not correspond with the reality of clinical practice.[4] Moreover, including this criterion would expand the list of exclusion criteria, and the external validity of such a study would be low. Cognitive impaired patients are often excluded from research, due to ethical reasons or memory-based research methods. The remaining population is not representative anymore; hence we included cognitive impaired patients in the hospital phase. Studying the effects of extra protein in these patients at home would have been relevant, but including them was not possible, because our measurements involved memory-dependent questionnaires. Although excluding these patients led to a selection of older adults in the home phase, we do not think this affected the results. Actually, these enriched products are ideal for cognitive impaired elderly because they simply replace products without changing habits.

Study design: intervention

With ad libitum provision of enriched foods and drinks as part of the daily menu we remained close to real-life practice, which was a major strength of our study. Previous interventions have mainly been limited to oral nutritional supplements (ONS) in a prescribed dose.[5-10] Of the range of foods provided, protein intake of the intervention group was mainly increased by the following protein-enriched products: bread, dairy drinks, dairy desserts, soups, and fruit juices. Contribution of veal, instant mashed potatoes, and porridge was negligible. To our knowledge, only two other studies have used regular protein-enriched products (bread and drinking yoghurt) but these were offered every day actively [11,12], which influences eating behavior and does not reflect reality. Because we had an ad libitum intervention, the outcomes are more valid to a larger target group. In the intervention period, intake was higher in both groups than in the follow-up period in which subjects did not receive any products, suggesting a food delivery service is a great way to improve consumption. Positive results of meal delivery services on dietary intake and nutritional status of older adults have been shown before.[13,14] However, these services were provided without charge for the participants, and costs of these services in real life were not taken into account while this could influence the number of meals a person orders per week. It should be studied what older adults think a meal service may cost, and how price influences their behavior.

Study design: treatment of control group

Our control group had a high protein intake, which may have attenuated the effects on performance. Part of the protein intake in the control group was from the natural protein-rich products that we supplied. Providing the control group with these products was both a methodological and an ethical choice: we did not want to give the control group less attention and we did not want to oppose current dietetic advice by giving them placebo products low in protein. Therefore, their protein intake was higher than found in literature.[2,3,6,10,11,15] We assume that in groups with a lower protein intake, performance could have improved more by the protein-enriched products.

Outcome measures

We chose to focus on functionality outcomes, because physical function is related to independence in activities of daily living (ADL) which we want to improve after hospitalization. The Health Council also recommended to study functionality, next to more clinical outcomes such as mortality.[1] We chose not to focus on underlying mechanistic outcomes, such as muscle mass or muscle biopsies, because these measurements were not feasible at home. We carefully chose outcome measures, including physical performance and leg muscle strength, which had been shown before to improve with increasing protein intake.[5,16-20]

Future research recommendations

From the studies in this thesis we now know that protein-enriched foods and drinks help older adults to consume more protein, and possibly help accelerate recovery in those with low protein intakes. However, it was not possible to address all questions posed by the Health Council about treatment of undernutrition. For instance, we did not measure the effect of protein supplementation on mortality, one of the outcomes the Health Council requested.[1] To study effects on mortality, many subjects would be needed (estimation: 1000 in total), so a multi-center study is required. With sufficient resources it is possible to do this, but several practical and ethical restrictions exist. More importantly, we should ask ourselves whether mortality is an appropriate outcome measure in this study population. In my opinion, we should focus primarily on maintaining function to increase the independence of older adults, which consequently may reduce health care costs. Other relevant outcomes are reduction of hospital stay, readmissions, and amount and intensity of care needed. A systematic review and meta-analysis (2012) showed beneficial effects of high-protein ONS on several clinical, nutritional, and functional outcomes, including reduced hospital stay and readmissions.[21] It seems likely that protein-enriched products have similar effects because they effectively increase protein intake.

Whether the intake of 1.2-1.5 g/kg/d was needed for each of our subjects can be discussed, because protein requirements are dependent on individual energy and protein turnover.[22] International expert groups advised to increase the targets for protein intake for ill older adults to 1.2-1.5 g/kg/d.[16,17,23] Our research followed that advice, and although no beneficial effects on performance were found in our study, there is growing consensus on this higher protein target.[19] Other patients may also benefit from protein-enriched products, for example patients with gastro-intestinal disease, cancer patients, or surgical patients.[24-28]

Due to practical constraints we did not include an exercise component, but exercise has been shown to improve muscle mass and physical performance of older adults [29-33], as has been shown for the combination of resistance-type exercise and protein supplementation.[34] Combining an exercise program with our protein-enriched products could be a viable intervention for the long-term and give better results on physical performance. What remains to be studied is whether increasing total daily protein intake to a level of 1.2 g/kg/d is as effective as having a protein intake of 25-30 g per main meal, both in combination with exercise.

Besides studying the combination of exercise and an increased protein intake, we should investigate alternatives for exercise which are feasible during hospitalization, counteracting rapid muscle loss during the first days of bed rest.[20] During these days patients are very ill and weak, and exercising is usually not an option. A passive way to stimulate muscle protein synthesis is neuromuscular electro stimulation (NMES), which has been shown to stimulate muscle protein synthesis rates by invoking involuntary muscle contractions.[20,35-37] It should be studied if a combination of NMES and protein-enriched products leads to less muscle loss during hospitalization, and thereby improving recovery and/or limiting hospital stay and health care costs.

Increasing protein intake; who cares? Implications for public health and clinical practice

After the observational study, the departments of geriatric medicine and pulmonary medicine chose to adjust their policy and now provide every patient of 65 years and older with a protein- and energy-rich diet, except the patients with renal insufficiency. Further implementation in other departments and in other hospitals should be considered. By making protein-enriched foods and drinks the standard choice, more older patients will meet protein recommendations which will support them to recover from their illness. The same goes for long term care, including rehabilitation centers, residential care homes, and nursing homes. In my opinion, we should leave the responsibility of making the 'optimal choice' with managers of these care organizations by adjusting menus, not with the residents.

With the implementation of these protein-enriched products, extra costs will be a point of consideration. The products can be added to the menu without changing the logistics of the food service itself, but these products may cost more than regular foods and drinks do. However, health economic studies have shown that using ONS saves costs per patient and decreases length of hospital stay.[38] Similar effects are expected of protein-enriched foods and drinks, suggesting that extra costs for these products can be cost-effective as well. We expect, however, that cost-benefit analyses will be needed to convince health care managers to implement these products in their organization. For such studies, collaboration with experts in health care economics is necessary.

Something we could not address in our research was how to get the products to people at home in real life; what kind of services would be needed? Should the products be available in supermarkets? And if so, how should these be promoted? Or should they be available via the pharmacy? When these products become available for consumption at home, a question arises on who will pay for these products. Do we expect patients to pay for them themselves, or will they get reimbursed? The latter seems fair when a dietitian or physician could prescribe the products, considering the existing reimbursement for ONS. However, consequences for health care costs of both options need to be explored further.

Overall conclusion

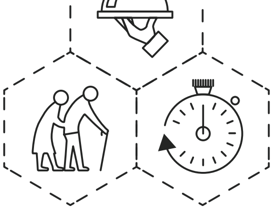
With the protein-enriched familiar foods and drinks, we have a feasible, acceptable, and appetizing long-term strategy to increase protein intake of older adults in various settings. We envisage a beneficial role of these protein-enriched products in combination with physical activity in older adults with lower protein intakes.

References

1. Health Council of the Netherlands. Undernutrition in the elderly. The Hague, 2011.
2. Tieland M, Borgonjen-Van den Berg KJ, van Loon LJC, de Groot LC. Dietary protein intake in community-dwelling, frail, and institutionalized elderly people: scope for improvement. Eur J Nutr 2012; 51(2): 173-9.
3. Tieland M, Borgonjen-Van Den Berg KJ, Van Loon LJC, de Groot LCPGM. Dietary protein intake in dutch elderly people: A focus on protein sources. Nutrients 2015; 7(12): 9697-706.
4. van Asselt DZB, Olde Rikkert MGM. Health Council of the Netherlands underestimates interactions in undernutrition in the elderly. Ned Tijdschr Geneeskd 2012; 156(3): A4446.
5. Tieland M, van de Rest O, Dirks ML, et al. Protein Supplementation Improves Physical Performance in Frail Elderly People: A Randomized, Double-Blind, Placebo-Controlled Trial. J Am Med Dir Assoc 2012; 13(8): 720-6.
6. Neelemaat F, Lips P, Bosmans JE, Thijs A, Seidell JC, van Bokhorst-de van der Schueren MAE. Short-term oral nutritional intervention with protein and & vitamin D decreases falls in malnourished older adults. J Am Geriatr Soc 2012; 60(4): 691-9.
7. Norton C, Toomey C, McCormack WG, et al. Protein Supplementation at Breakfast and Lunch for 24 Weeks beyond Habitual Intakes Increases Whole-Body Lean Tissue Mass in Healthy Older Adults. The Journal of Nutrition 2016; 146(1): 65-9.
8. Milne AC PJ, Vivanti A, Avenell A. . Protein and energy supplementation in elderly people at risk from malnutrition. Cochrane Database of Systematic Reviews 2009; (2).
9. Allen VJ, Methven L, Gosney MA. Use of nutritional complete supplements in older adults with dementia: Systematic review and meta-analysis of clinical outcomes. Clin Nutr 2013.
10. Bally MR, Blaser Yildirim PZ, Bounoure L, et al. Nutritional support and outcomes in malnourished medical inpatients: A systematic review and meta-analysis. JAMA Internal Medicine 2016; 176(1): 43-53.
11. Stelten S, Dekker IM, Ronday EM, et al. Protein-enriched 'regular products' and their effect on protein intake in acute hospitalized older adults; a randomized controlled trial. Clin Nutr; 34(3): 409-14.
12. van Til A, Naumann E, Cox-Claessens I, Kremer S, Boelsma E, de van der Schueren MA. Effects of the daily consumption of protein enriched bread and protein enriched drinking yoghurt on the total protein intake in older adults in a rehabilitation centre: A single blind randomised controlled trial. J Nutr Health Aging 2014; 19(5): 525-30.
13. Frongillo EA, Wolfe WS. Impact of participation in home-delivered meals on nutrient intake, dietary patterns, and food insecurity of older persons in New York State. J Nutr Elder 2010; 29(3): 293-310.
14. Kretser AJ, Voss T, Kerr WW, Cavadini C, Friedmann J. Effects of two models of nutritional intervention on homebound older adults at nutritional risk. J Am Diet Assoc 2003; 103(3): 329-36.
15. Manning F, Harris K, Duncan R, et al. Additional feeding assistance improves the energy and protein intakes of hospitalised elderly patients. A health services evaluation. Appetite 2012; 59(2): 471-7.
16. Bauer J, Biolo G, Cederholm T, et al. Evidence-Based Recommendations for Optimal Dietary Protein Intake in Older People: A Position Paper From the PROT-AGE Study Group. J Am Med Dir Assoc 2013; 14(8): 542-59.
17. Deutz NEP, Bauer JM, Barazzoni R, et al. Protein intake and exercise for optimal muscle function with aging: Recommendations from the ESPEN Expert Group. Clin Nutr 2014; 33(6): 929-36.
18. Wolfe RR, Miller SL, Miller KB. Optimal protein intake in the elderly. Clin Nutr 2008; 27(5): 675-84.
19. Paddon-Jones D, Campbell WW, Jacques PF, et al. Protein and healthy aging. The American Journal of Clinical Nutrition 2015; 101(6): 1339S-45S.
20. English KL, Paddon-Jones D. Protecting muscle mass and function in older adults during bed rest. Curr Opin Clin Nutr Metab Care 2010; 13(1): 34.
21. Cawood A, Elia M, Stratton R. Systematic review and meta-analysis of the effects of high protein oral nutritional supplements. Ageing Research Reviews 2012; 11: 278-96.
22. Elia M. Insights into energy requirements in disease. Public Health Nutr 2005; 8(7a): 1037-52.
23. Nordic Council of Ministers. Nordic Nutrition Recommendations 2012: Integrating nutrition and physical activity, 2014.
24. Beck AM, Holst M, Rasmussen HH. Oral nutritional support of older (65 years+) medical and surgical patients after discharge from hospital: systematic review and meta-analysis of randomized controlled trials. Clin Rehabil 2013; 27(1): 19-27.
25. Senesse P, Assenat E, Schneider S, et al. Nutritional support during oncologic treatment of patients with gastrointestinal cancer: Who could benefit? Cancer Treat Rev 2008; 34(6): 568-75.

26. Norman K, Kirchner H, Freudenreich M, Ockenga J, Lochs H, Pirlich M. Three month intervention with protein and energy rich supplements improve muscle function and quality of life in malnourished patients with non-neoplastic gastrointestinal disease—A randomized controlled trial. Clin Nutr 2008; 27(1): 48-56.
27. Gillis C, Loiselle SE, Fiore JF, et al. Prehabilitation with Whey Protein Supplementation on Perioperative Functional Exercise Capacity in Patients Undergoing Colorectal Resection for Cancer: A Pilot Double-Blinded Randomized Placebo-Controlled Trial. J Acad Nutr Diet 2016; 116(5): 802-12.
28. Liu M, Yang J, Yu X, et al. The role of perioperative oral nutritional supplementation in elderly patients after hip surgery. Clin Interv Aging 2015; 10: 849-58.
29. Peterson MD, Rhea MR, Sen A, Gordon PM. Resistance exercise for muscular strength in older adults: A meta-analysis. Ageing Research Reviews 2010; 9(3): 226-37.
30. Peterson MD, Sen A, Gordon PM. Influence of Resistance Exercise on Lean Body Mass in Aging Adults: A Meta-Analysis. Med Sci Sports Exerc 2011; 43(2): 249-58.
31. Fiatarone MA, Marks EC, Ryan ND, Meredith CN, Lipsitz LA, Evans WJ. High-intensity strength training in nonagenarians: Effects on skeletal muscle. JAMA 1990; 263(22): 3029-34.
32. Fiatarone MA, O'Neill EF, Ryan ND, et al. Exercise Training and Nutritional Supplementation for Physical Frailty in Very Elderly People. N Engl J Med 1994; 330(25): 1769-75.
33. Drey M, Zech A, Freiberger E, et al. Effects of Strength Training versus Power Training on Physical Performance in Prefrail Community-Dwelling Older Adults. Gerontology 2012; 58(3): 197-204.
34. Tieland M, Dirks ML, van der Zwaluw N, et al. Protein Supplementation Increases Muscle Mass Gain During Prolonged Resistance-Type Exercise Training in Frail Elderly People: A Randomized, Double-Blind, Placebo-Controlled Trial. J Am Med Dir Assoc 2012.
35. Wall BT, Morton JP, van Loon LJC. Strategies to maintain skeletal muscle mass in the injured athlete: Nutritional considerations and exercise mimetics. European Journal of Sport Science 2015; 15(1): 53-62.
36. Wall BT, Dirks ML, Verdijk LB, et al. Neuromuscular electrical stimulation increases muscle protein synthesis in elderly type 2 diabetic men. American Journal of Physiology - Endocrinology and Metabolism 2012; 303(5): E614-E23.
37. Dirks Marlou L, Hansen D, Van Assche A, Dendale P, Van Loon Luc JC. Neuromuscular electrical stimulation prevents muscle wasting in critically ill comatose patients. Clin Sci 2015; 128(6): 357-65.
38. Freijer K, Nuijten MJC. Analysis of the health economic impact of medical nutrition in the Netherlands. 2010; 64(10): 1229-34.

Summary



Protein undernutrition is a major health concern for older adults, especially for those who are ill. There is growing consensus for a protein intake target of 1.2 - 1.5 gram per kg bodyweight per day (g/kg/d) for these older adults. However, this target is not reached by the majority of older adults. Therefore, more effective and novel strategies to increase protein intake are warranted, including the use of protein-enriched foods and drinks. This thesis evaluated the impact of the developed protein-enriched foods and drinks on protein intake and physical performance among older adults. The studies in this thesis were done as part of the Cater with Care® project; a collaboration between the university, care organizations, and partners from the food industry. The industrial partners developed the products, focusing each on different product categories: Carezzo Nutrition developed bread, pastry, and fresh juices and soups; The Kraft Heinz Company focused on long shelf-life and convenience foods; and the Veal Promotion Foundation produced veal meat.

To fit the products to the needs of the target group, interviews with undernourished older adults (at home or hospitalized) and with dietitians were conducted (**chapter 2**). These interviews showed that undernutrition awareness is low among older adults. To treat undernutrition by changing their eating habits, older adults need to be aware of their health problem, they need to be willing to change, and they need to be able to understand and implement the dietitian's advices. This process takes time while undernutrition should be treated immediately. For immediate treatment, enriched products could be used, without first creating awareness. According to the interviewees, enriched products should fit within older adults' eating habits, and have small portion sizes.

To gain insights in food choices of hospitalized older adults (65 years and older) an observational study was conducted. In this study, energy and protein intakes of 80 hospitalized older patients at low and high risk of undernutrition were assessed (**chapter 3**). Patients who received an energy- and protein-rich menu, because of their risk of undernutrition, were better able to reach the protein and energy targets than patients with a low risk of undernutrition receiving a standard menu. Based on these results we proposed that all hospitalized older adults – both at low and high risk of undernutrition – should receive an energy- and protein-rich menu.

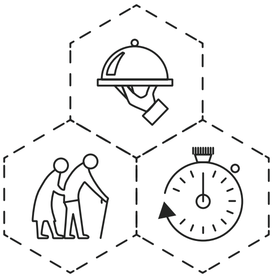
Subsequently, a pilot study was done in a care home and a rehabilitation center with the aim to explore the potential of the developed protein-enriched products to increase protein intake (**chapter 4**). Participants did not compensate their consumption of regular protein-rich foods (e.g. dairy, cheese) upon the introduction of protein-enriched foods and drinks. The 22 institutionalized elderly (mean age 83 years) consumed 12 gram protein per day more than they did before the intervention. Consequently, more people met the protein target of 1.2 g/kg/d than before the intervention. We concluded that protein-enriched products enabled institutionalized elderly to reach protein intake targets. Furthermore, we gained valuable feedback to improve the assortment of protein-enriched products for the effectiveness study.

In the final study, effects of the protein-enriched products on protein intake and physical performance were studied in a randomized controlled trial during hospitalization and subsequent recovery at home. During the hospital period in which 147 older patients participated, patients that received protein-enriched products increased their protein intake compared to the control group that already received a protein-rich hospital menu (**chapter 5**). As a result, 79% of the intervention group reached a protein intake of 1.2 g/kg/d, compared to 48% of the control group. Finally, effects of the protein-enriched products were tested at home, for a longer period (**chapter 6**). Half of the hospital phase participants (n = 75) continued the intervention at home for 12 weeks. The protein-enriched products were successfully implemented in the daily menu of the older adults: the intervention group had a higher average protein intake (1.5 ± 0.6 g/kg/d) than the control group (1.0 ± 0.4 g/kg/d) during the 12-week intervention period. Seventy-two percent of the intervention group reached a protein intake of 1.2 g/kg/d during the 12-week intervention, compared to 31% of the control group. Protein intake of the intervention group was mainly increased by the following protein-enriched products: bread, dairy drinks, dairy desserts, soups, and fruit juices. However, despite the successful improvement of protein intake, we found no added value on physical performance in the first 6 months after hospitalization.

It was concluded that with the protein-enriched familiar foods and drinks, we have a feasible, acceptable, and appetizing long-term strategy to increase protein intake of older adults in various settings. We envisage a beneficial role of these protein-enriched products in combination with physical activity in older adults with lower protein intakes.

Dutch summary

Nederlandse samenvatting



Ondervoeding bij ziekte is een erkend zorgprobleem en met name een onvoldoende eiwitinname is een zorg bij ouderen. Acuut of chronisch zieke ouderen wordt aanbevolen om dagelijks 1.2-1.5 gram eiwit per kg lichaamsgewicht per dag (g/kg/d) te consumeren. Dit doel wordt helaas door de meerderheid van de ouderen niet behaald. Er is daarom behoefte aan innovatieve en effectieve strategieën om eiwit inname te verhogen, waarbij we kunnen denken aan het verrijken van voedingsmiddelen met eiwit. In dit proefschrift wordt de impact van eiwitverrijkte voedingsmiddelen op eiwitinname en fysiek functioneren van ouderen geëvalueerd. De onderzoeken die beschreven worden in dit proefschrift zijn uitgevoerd als onderdeel van het Cater with Care® project; een samenwerking tussen de universiteit, zorginstellingen en voedingsmiddelenbedrijven. De bedrijven ontwikkelden de producten, ieder met een andere focus: Carezzo Nutrition ontwikkelde bakkerijproducten, verse sappen en verse soepen, The Kraft Heinz Company legde zich toe op de lang houdbare producten en Stichting Promotie Kalfsvlees produceerde kalfsvleesproducten.

Om de producten aan de behoeften en wensen van de doelgroep aan te passen werden interviews gehouden met ondervoede ouderen (zowel thuis als in het ziekenhuis) en met diëtisten (**hoofdstuk 2**). Deze interviews leerden ons dat ouderen zich vaak niet bewust zijn dat ze ondervoed zijn. Om ouderen goed te kunnen behandelen, moet er bewustzijn gecreëerd worden, en moeten de ouderen ervoor open staan om aanpassingen te doen in het eetpatroon. Verder is het van belang dat ze de adviezen van de diëtist goed begrijpen om ze ook toe te kunnen passen. Dit bewustmakings- en leerproces heeft tijd nodig, terwijl ondervoeding zo snel mogelijk aangepakt moet worden. Om ondervoeding snel te kunnen behandelen, kunnen eiwitverrijkte producten ingezet worden. Deze producten moeten volgens de geïnterviewde ouderen en diëtisten passen binnen het eetgedrag van de ouderen, en producten moeten in kleine porties beschikbaar zijn vanwege het gebrek aan eetlust.

Om meer inzicht te krijgen in de voedselkeuzes van oudere patiënten (65 jaar en ouder) tijdens ziekenhuisopname, hebben we een observationele studie uitgevoerd bij 80 patiënten waarvan de helft een laag risico op ondervoeding had en de andere helft een hoog risico volgens de screening. Van deze 80 patiënten werd de energie- en eiwitinname beoordeeld (**hoofdstuk 3**). De patiënten die een energie- en eiwitrijk menu kregen, vanwege hun verhoogde risico op ondervoeding, waren beter in staat de energie- en eiwitdoelen te behalen dan degenen met een laag risico die het normale menu kregen. We concludeerden dat alle oudere patiënten, zowel degenen met een laag als hoog risico op ondervoeding, een energie- en eiwitrijk menu zouden moeten krijgen gedurende ziekenhuisopname.

Daarna is een pilot-onderzoek uitgevoerd in een verzorgingshuis en een revalidatiecentrum waarin onderzocht werd in hoeverre de eiwitverrijkte producten eiwitinname konden beïnvloeden (**hoofdstuk 4**). Deelnemers verruilden andere eiwitrijke producten, zoals zuivel en vlees, niet voor de eiwitverrijkte producten en er was dus geen sprake van compensatie voor de verrijking. De 22 ouderen (gemiddelde leeftijd van 83 jaar) hadden gedurende de interventieperiode van 10 dagen een hogere eiwitinname dan voor de interventie: 12 gram per dag. Hierdoor behaalden meer mensen het eiwitdoel van 1.2 g/kg/d dan voor de interventie. We concludeerden dat eiwitverrijkte producten ouderen in een verzorgingshuis en revalidatiesetting hielpen hun eiwitinname te verhogen. Daarnaast gaven de deelnemers ook waardevolle terugkoppeling over de producten waardoor deze verbeterd konden worden voor de effectstudie.

Door middel van een gerandomiseerde gecontroleerde studie onderzochten we de effecten van de eiwitverrijkte producten op eiwitinname en fysiek functioneren van ouderen gedurende en na ziekenhuisopname. Gedurende de ziekenhuisfase waar 147 oudere patiënten (65 jaar en ouder) aan mee deden, behaalden degenen die het interventiemenu (inclusief Cater with Care® eiwitverrijkte producten) kregen, een hogere eiwitinname dan de controlegroep dit het gebruikelijke energie- en eiwitrijke menu kreeg (**hoofdstuk 5**). Dit resulteerde in maar liefst 79% van de interventiegroep dat de eiwittarget van 1.2 g/kg/d behaalde, in vergelijking tot 48% van de controlegroep. Uiteindelijk werden de eiwitverrijkte producten ook voor langere tijd getest door patiënten thuis (**hoofdstuk 6**). Ongeveer de helft van de deelnemers in het ziekenhuis (75 patiënten) wilden het onderzoek thuis voortzetten. Gedurende 12 weken kregen ze pakketjes van ons verstrekt. De interventiegroep kreeg de eiwitverrijkte producten, de controlegroep kreeg reguliere, niet verrijkte producten. Metingen werden gedaan op de dag voor ontslag uit het ziekenhuis, en na 2, 6, 12 en 24 weken na ziekenhuisopname.
De eiwitverrijkte producten verhoogden de eiwitinname van de interventiegroep met succes: de interventiegroep had gedurende de 12 weken-durende interventieperiode een hoger gemiddelde eiwitinname (1.5 g/kg/d) dan de controlegroep (1.0 g/kg/d). Gedurende deze periode, behaalde 72% van de interventiegroep en 31% van de controlegroep het eiwitdoel van 1.2 g/kg/d. De volgende eiwitverrijkte producten verhoogden de eiwitinname van de interventiegroep het meest succesvol: brood, zuiveldranken, zuiveltoetjes, soepen, en fruitsappen. Ondanks de positieve resultaten op eiwitinname, zagen we geen meerwaarde van de producten op fysiek functioneren van de ouderen gedurende de eerste 6 maanden na ziekenhuisopname.

Van de onderzoeken in dit proefschrift kunnen we concluderen dat we met eiwitverrijkte voedingsmiddelen een haalbare, acceptabele, en smakelijke strategie hebben om effectief de eiwitinname van ouderen voor een langere periode te verhogen. De producten kunnen daarbij zowel in de langdurige zorg, als in het ziekenhuis, als thuis gebruikt worden. We verwachten dat eiwitverrijkte producten, in combinatie met fysieke activiteit, fysiek functioneren van ouderen met een lage eiwitinname kunnen verbeteren.

Acknowledgements

Dankwoord

It's a wrap! Toen ik mijn proefschrift printte, verbaasde ik me er weer eens over dat 4 jaar werk in een klein pakketje papier resulteerde. Terwijl er zo veel werk, tijd, en mensen nodig zijn geweest om deze onderzoeken uit te voeren. Ik wil nu dan ook graag even de ruimte nemen om iedereen te bedanken.

Om te beginnen wil ik mijn begeleiders bedanken: Lisette, Frans en Nicole. Lisette, wat had ik een geluk met jou als promotor. De eerste twee jaar hebben we elkaar niet zo veel gezien, je vertrouwde erop dat Nicole en ik het Cater with Care project goed aanpakten. De laatste twee jaar moest er meer en meer geschreven worden. Jouw kennis en kritische vragen ("wat is je boodschap?") hebben mijzelf en de artikelen naar een hoger niveau getild. Je deur stond altijd open, bedankt voor alles! Frans, ook al ging je vorig jaar met pensioen, je bleef betrokken op de achtergrond. Bedankt voor alle kritische vragen en feedback. Last, but certainly not least: Nicole! Je was de beste copromotor die ik me maar kon wensen: altijd stond je deur open om even snel te sparren, maar ook voor gezellige koffiepauzes. Samen hebben we heel wat projectvergaderingen mee gemaakt, en daarnaast ook een gezellige tijd gehad in Lissabon bij ESPEN. Er moest natuurlijk ook geschreven worden.. Jij nam er altijd de tijd voor om constructieve feedback te geven, geen zin werd overgeslagen met jouw taalkundig perfectionisme. En dan was je vaak ook nog de eerste die het alweer terug stuurde (soms wel heel snel.. dacht ik er voor even vanaf te zijn). Nicole, bedankt voor de fijne samenwerking!

Zonder deelnemers geen onderzoek; alle deelnemers hartelijk bedankt voor uw tijd en energie om mee te doen aan de studies in dit proefschrift.

I would like to thank the committee Kees de Graaf, Anne Marie Beck, Marian de van der Schueren and Dieneke van Asselt for reading my thesis and being present at my defence.

Het Cater with Care project was een samenwerking tussen veel partijen, en veel mensen waren betrokken: alle projectpartners, bedankt! Speciaal wil ik een aantal mensen van Ziekenhuis Gelderse Vallei bedanken. Emmelyne en Nancy, ik heb veel van jullie geleerd over het wel en wee in een ziekenhuis, maar vooral ook over de doelgroep. Emmelyne, jij was mijn sparringpartner in het ziekenhuis: uren hebben we gepraat over het onderzoek. We liepen vaak tegen dezelfde problemen aan, gelukkig konden we die samen oplossen. Bedankt voor alle ideeën, input voor artikelen, en niet te vergeten gezelligheid! Nancy, jouw ervaring als diëtist was super waardevol voor mij en het project. Bedankt dat je altijd mee dacht, en voor de Limburgse gezelligheid! André, bedankt voor alle waardevolle input voor het project en de studies. Wout, bedankt voor al je werk tijdens de studie in het ziekenhuis. Je werd even snel ingewerkt om Emmelyne te vervangen en deed dit super. Bedankt voor je harde werk en voor de fijne gesprekken. Veel succes met je eigen promotietraject!

Drie mensen zorgden er voor dat niet ík, maar het project door draaide tijdens de effectstudie. Astrid, je was de beste (personal) assistant! Slim, efficiënt, handig met data, en je zorgde ook nog voor koffie. Bedankt voor je enthousiasme en doorzettingsvermogen! Heel veel succes nog met je promotietraject in Amsterdam, komt helemaal goed jouw kennende. Renske, toen je nog als student bij de EET studie aan de slag ging, was ik al onder de indruk van jouw omgang met de oudere deelnemers. Het gaf een hoop rust dat jij tijdens de effectstudie de dagboekjes kon invoeren en met metingen mee ging waar nodig. Bedankt voor je inzet en gezelligheid! Anne, bedankt voor jouw niet-lullen-maar-doen instelling, ik hoefde me geen zorgen te maken over de logistiek of om Kjeldahl bepalingen. En natuurlijk bedankt dat je mijn stok achter de deur was bij Bosu, was gezellig!

Els, als het over voedingsproeven gaat, dan moet je bij jou zijn! Bedankt voor alle bestellingen en het meedenken over vriezers en koelkasten. Corine a.k.a. mijn "Compl-Eat hulplijn", bedankt dat je altijd super snel je checks deed en weer een nieuwe uitdraai klaar had!

Renske, Joyce, Sygrit, Marleen, Kiki, Anne, Emilie, Myrte, Cora, Rick, Merel, Marieke, Vera en Juul, ik vond het erg leuk om jullie te begeleiden bij een thesis of stage. Voor de Cater with Care onderzoeken zochten we studenten die graag ook praktisch werk deden. Nou, dat hebben jullie volgens mij wel geweten. Bedankt voor al jullie inzet tijdens alle voorbereidingen, metingen en ritjes met pakketjes!

Ik heb van begin tot eind een heel gezellige werkplek gehad in het Agrotechnion. Ten eerste mijn roomie Annemarie, wat was het gezellig met jou in kamer 3013 en wat hebben we een hoop gedeeld. Bedankt voor je gezelligheid! Ondertussen zijn Linde, Martinet, Eveline en Vera al een hele tijd vertrokken, maar wat heb ik een lol met jullie gehad! Cornelia, jij hoort daar natuurlijk ook bij (ook al zat je in het Biotechnion), bedankt voor alle gezelligheid en nuchtere kijk op het leven! Wanneer gaan we weer eens pub-quizzen? Sandra, je bent een topper, bedankt voor het mee denken en je droge humor! Alle Agrotechnion collega's: bedankt voor alle lunches, wandelingen en borrels. Nadat Annemarie vertrok, kwamen Yfke en Moniek, zo ongeveer om de beurt, checken of ik nog niet weg zat te kwijnen in mijn eentje, of was dit eigenlijk werk-ontwijkend-gedrag?! Anyway, ik vond het erg gezellig met jullie! PhD tour commissie 2015 (Guido, Irene, Juri, Merel, Moniek en Yfke), we waren een top team! Bedankt voor de leuke tijd voor, tijdens en na de tour! Louise, samen de regeltjes uitvogelend gingen we naar de eindstreep, en dit hebben we goed gevierd. Succes met jouw verdediging! Karen, Jacqueline en Jasmijn, bedankt voor al jullie hulp bij allerlei vragen, jullie zijn top!

Work hard, play hard! Gezellige etentjes met de miepjes, de Oude Garde, en Kelly en Ingrid (eigenlijk dus allemaal miepjes) waren gezellige afleiding, bedankt hiervoor! Ellen, Nikkie en Sophie, wat gezellig om vriendinnen als collega's te hebben! Gezellig samen eten, naar wijn proeverijen, of gewoon koffieleuten. Lisa, jou wil ik nog extra bedanken voor je werk voor de EET studie. Super hoe je met de deelnemers (die niet altijd even gemakkelijk waren) om ging! Mijn vrienden en vriendinnen 'thuis-thuis' zorgen er voor dat Limburg nog als mijn echte thuis voelt. Fieke, Froukje, Kelly, Lieke en Nieke, hoe bijzonder is het dat we al sinds de basisschool bevriend zijn! Annita, Anouk, Jonna, Lieke, Linda, Lotte en Monique: altijd in voor gezelligheid en feestjes. Ik hoop dat we er nog veel samen mogen beleven! Matties in Ysselsteyn, ook al was ik de laatste tijd sjaak-afhaak, wat is het fijn om lekker slap te ouwehoeren met jullie in de kroeg. Jeroen, wat vind ik het fijn dat jij mijn kaft wilde ontwerpen en de lay-out wilde doen, bedankt voor al je creativiteit en tijd & thanks for being my friend!

Canan, volgens mij hebben we al vrij snel besloten dat we elkaars paranimf gingen worden. In de afgelopen 4 jaar ben je echt een vriendin geworden waarmee ik eindeloos kon praten, zowel over het werk als over tientallen series. Met jouw enthousiasme kon je me altijd weer even oppeppen, super bedankt! Op naar jouw verdediging! Mow, ik denk niet dat er ooit iemand zo enthousiast heeft gesolliciteerd naar de functie van paranimf ;-) Samen op vakantie naar Curaçao, filosoferen over de toekomst, of gewoon lekker flauwe grappen maken onder het genot van een wijntje.. allemaal even waardevol!

Joep, Marian en Loes, jullie mag ik ondertussen ook wel familie noemen, bedankt dat jullie deur altijd open staat! Opa en oma, ik ben blij dat jullie er bij kunnen zijn tijdens de verdediging. Bedankt dat jullie, wat Toon en ik ook doen, trots op ons zijn! Grote-kleine broer, jij bent nooit te beroerd om te helpen met verhuizen, ritjes naar Wageningen maken of wat dan ook, bedankt toppertje! Pap en mam, ik kan altijd met alles bij jullie terecht en jullie zijn no matter what trots op me. Jullie zijn de liefste!

Het feit dat een stelling geïnspireerd is door Tika, zegt waarschijnlijk genoeg ;-)

De allerlaatste woorden zijn natuurlijk voor Jesper: de afgelopen jaren zijn voor jou niet altijd gemakkelijk geweest. Bedankt dat je op me wacht, dat je me altijd aan het lachen maakt, naar me luistert wanneer ik weer uit moet razen, en me zo nodig weer met beide benen op de grond zet of afremt. Op naar ons nieuwe avontuur, ik hoop er nog heel veel samen te beleven!

Janne

About the author

Curriculum Vitae

Janne Beelen was born on October 5th, 1987 in Venray, The Netherlands. In 2006, she received her secondary school diploma from Raayland College in Venray. Shortly thereafter, she moved to Wageningen to pursue her post-secondary education in 'Nutrition and Health'. She did her MSc thesis in collaboration with hospital Gelderse Vallei in Ede, during which she studied the association between caffeine intake and premature ventricular complexes. She completed her internship at the University of Newcastle, Australia, where she investigated how to improve diet quality of families, and worked on several research projects. Shortly after her MSc graduation in 2011, she worked as a research assistant on the Chew It! Study measuring oral processing of foods. In 2012, Janne started her PhD within the Cater with Care project. Her project focused on developing and testing protein-enriched foods and drinks for the elderly. During this PhD project, Janne conducted intervention studies aiming to improve protein intake of older patients and studying the effects on their physical performance. The Cater with Care project was a public-private collaboration, which was financially supported by a grant from the GO EFRO 2007-2013 program. During her PhD, she joined the educational programme of the Graduate School VLAG, and was chair of the organising committee of the academic excursion for fellow PhD candidates to the East Coast of United States in 2015. In 2016 Janne was selected to participate in the 22nd seminar of the European Nutrition Leadership Platform. She has co-taught both bachelor and master level courses in the 'Nutrition and Health' programme, and supervised MSc thesis students.

List of Publications

Peer reviewed publications

Beelen J, de Roos NM, de Groot CPGM. Protein enrichment of familiar foods as an innovative strategy to increase protein intake in institutionalized elderly. Journal of Nutrition, Health and Aging, 2016. doi: 10.1007/s12603-016-0733-y. e-pub: 21 April 2016.

Submitted papers

Beelen J, Vasse E, Ziylan C, Janssen N, de Roos NM, de Groot CPGM. Undernutrition: who cares? Perspectives of dietitians and elderly patients on undernutrition treatment. Submitted

Beelen J, Vasse E, de Roos NM, Janssen N, de Groot CPGM. A protein and energy enriched diet should not be restricted to only malnourished hospitalized elderly people. Submitted

Beelen J, Vasse E, Janssen N, Janse A, de Roos NM, de Groot CPGM. Protein-enriched familiar foods and drinks improve protein intake of hospitalized older patients: a randomized controlled trial. Submitted

Beelen J, de Roos NM, de Groot CPGM. Effects of a 12-week intervention with protein-enriched foods and drinks on protein intake and physical performance of older patients during the first 6 months after hospital release: the randomized controlled Cater with Care® trial. Submitted

Abstracts and presentations

Beelen J, Vasse E, Janssen N, van Geel J, de Roos NM, Kok FJ, de Groot CPGM. Cater with care: how can food intake in hospitalized elderly be improved? Results from an observational study among patients with and without risk of malnutrition. EUGMS (European Union Geriatric Medicine Society) annual congress, September 2014, oral presentation.

Janssen N, Vasse E, **Beelen J**, van der Sluijs Q, van Geel J, de Roos NM, Janse A
Cater with Care: Insights into Meeting Protein Requirements in Hospitalized Elderly Patients. European Society for Clinical Nutrition and Metabolism (ESPEN) annual congress, September 2014, poster presentation.

Beelen J, de Roos NM, de Groot CPGM. Protein enrichment of familiar foods as an innovative strategy to increase protein intake in institutionalized elderly. European Society for Clinical Nutrition and Metabolism (ESPEN) annual congress, September 2015, poster presentation.

Beelen J, Vasse E, Doorduijn A, de Roos NM, Janssen N, de Groot CPGM. Cater with Care: de effecten van herkenbare eiwitverrijkte producten voor oudere patiënten op eiwitinname gedurende ziekenhuisopname. 13e Nationaal Gerontologiecongres (NVG), October 2015, oral presentation.

Beelen J, de Roos NM, Vasse E, Janssen N, Janse A, de Groot CPGM. Eiwitverrijkte basisvoeding tijdens en na ziekenhuisopname: bevordert dit het herstel van oudere patiënten? Geriatriedagen, February 2016, oral presentation.

Beelen J, Vasse E, Janssen N, Janse A, de Roos NM, de Groot CPGM. Improving protein intake of hospitalized older patients with protein-enriched familiar foods and drinks: the randomized controlled Cater with Care® trial. European Society for Clinical Nutrition and Metabolism (ESPEN) annual congress, September 2016, poster presentation.

Beelen J, de Roos NM, de Groot CPGM. Effects of protein-enriched familiar foods and drinks on protein intake and physical recovery of older patients during 12 weeks in a transmural context: the randomized controlled Cater with Care® trial. European Society for Clinical Nutrition and Metabolism (ESPEN) annual congress, September 2016, oral presentation.

Overview of completed training activities

Discipline specific activities	Organizer and Location	Year
Courses and workshops		
Wet- en regelgeving voor klinisch onderzoek	Ziekenhuis Gelderse Vallei, Ede	2012
Workshop 'Voeding als medicijn voor ouderen'	RIVM, Bilthoven	2012
NutriScience - A multifaceted approach to nutrition research	VLAG, Wageningen	2013
Masterclass 'Public health technology assessment and economic evaluation - what is not valued is not counted'	Maastricht University/GGD Zuid-Limburg, Maastricht	2013
Conferences and meetings		
Nutritional Science Days	NWO, Deurne	2012
Health & Food Congres	Foodvision, Veghel	2012
Haal meer gezondheid uit voeding(smiddelen)	Voeding Nederland, Nieuwegein	2012
11e Nationaal Gerontologiecongres	NVG, Ede	2012
Focus op ondervoeding	Voeding Nu, Baarn	2012
Healthy Ageing conference	NCHA, Den Haag	2012
Nutritional Science Days	NWO, Deurne	2013
Symposium Gezonde voeding, gezond ouder worden	Humane Voeding WUR, Wageningen	2013
Congress of the European Union Geriatric Medicine Society	EUGMS, Rotterdam	2014
Congress of the European Society for Clinical Nutrition and Metabolism	ESPEN, Lisbon	2015
13e Nationaal Gerontologiecongres	NVG, Ede	2015
Geriatriedagen 2016	NVG/Nederlandse Vereniging voor Klinische Geriatrie, Den Bosch	2016
ENLP Essential Seminar 2016	European Nutrition Leadership Platform, Luxembourg	2016
Food for Thought	Alliantie Voeding, Ede	2012-2016

Discipline specific activities	Organizer and Location	Year
General courses and workshops		
VLAG PhD week	VLAG, Baarlo	2012
Data management	Wageningen UR Library, Wageningen	2013
Mini symposium: How to write a world class paper.	Wageningen UR Library, Wageningen	2013
PhD workshop carousel	WGS, Wageningen	2013
Scientific writing	WGS, Wageningen	2014
Techniques for writing & presenting a scientific paper	WGS, Wageningen	2015
Teaching and supervising thesis students	Educational Staff Development, Wageningen	2014
Optional courses and activities		
VLAG Proposal	HNE/VLAG, Wageningen	2012
PhD study tour organising committee 2015	HNE/VLAG, Wageningen	2015
PhD study tour 2015	HNE/VLAG, Wageningen	2015
Staff seminars	HNE, Wageningen	2012-2016

Colophon

The research described in this thesis was part of the Cater with Care® project and financially supported by a grant from the GO EFRO 2007-2013 program. Products and services were developed in the Cater with Care® consortium that existed of the following partners: Carezzo Nutrition BV, The Kraft Heinz Company, Stichting Promotie Kalfsvlees, NIZO food research BV, Sodexo, Ziekenhuis Gelderse Vallei, and Wageningen UR.

Financial support from Wageningen University for printing this thesis is gratefully acknowledged.

Cover and lay-out	Jeroen Gommers Jeroen Gommers Information Design, jeroengommers.nl, Tilburg NL
Printing	Digiforce, Proefschriftmaken.nl, Vianen NL