NUTRITION, DIETARY GUIDANCE, AND HOME-DELIVERED MEALS AMONG OLDER COMMUNITY-DWELLING PEOPLE

Susanna Kunvik

DOCTORAL DISSERTATION

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Cover picture of Kaarina Kunvik: Susanna Kunvik

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Dedicated to my grandmother Kaarina Kunvik, who was a domestic counselor and a member of Lotta Svärd, providing an important dietary guidance to families, especially in the post-war period.
ERRATA


Corrections

Page 4:
Incorrect character inside parentheses. Correction: “including caregivers (Studies I and IV)” → “including caregivers (Studies I – IV)”

Page 12:
ABSTRACT

Risk of malnutrition and insufficient nutrient intake, especially protein intake, are major concerns regarding older people living at home. As older people become more dependent on help, the risk of malnutrition increases. Also, older caregivers are under a heavy burden which can lead to depression and other health problems, causing nutritional problems. Supportive nutritional prevention and care has become an important issue to address in the community. Practical and realistic approaches are required to improve the nutrition of older people.

The aim of this doctoral dissertation was 1) to investigate the nutritional status, nutrient intake and factors associated with them among older (≥65 years) community-dwelling (living at home) caregivers and people receiving care (care recipients and home care clients), 2) to study the effectiveness of tailored dietary guidance with group meetings (Care Nutrition trial 2016-2017) on protein intake among older caregivers, males especially, and 3) to evaluate the effectiveness of two different eight-week home-meal services (Power Meals trial 2018) on protein intake and other nutrients, physical performance, and quality of life among older caregivers and people receiving care.

The study comprises two randomized controlled trials reporting the results from baseline (cross-sectional Studies I and III) and effectiveness of the interventions (Studies II and IV). The Care Nutrition trial (Studies I and II) and Power Meals trial (Studies III and IV) were conducted in the Pori Social and Health Services area in Finland. Both trials investigate community-dwelling older (≥65 years) people with normal cognition including caregivers (Studies I and IV), care recipients of the caregiver (Studies III and IV) and home care clients (Studies III and IV). Nutritional status was assessed with Mini Nutritional Assessment, nutrient intake with three-day food records, physical performance with Short Physical Performance Battery (including Sit-To-Stand test), hand grip strength with Hydraulic Hand Dynamometer, risk of sarcopenia with Simple Questionnaire to Rapidly Diagnose Sarcopenia, depression with Geriatric Depression Scale, quality of life with 15D instrument, cognition with Mini Mental State Examination, appetite with Simplified Nutritional Appetite Questionnaire, mean daily time of moderate-to-vigorous physical activity (MVPA), and daily steps and standing with an accelerometer during one week. During the six-month intervention in the CareNutrition trial, tailored dietary guidance was given to the intervention group (guidance group) during a home visit and in group meetings (2-4 times), complemented with written material. The written material was also offered to control group. In the Power Meals trial, the eight-week intervention in two
different groups included daily either a protein-rich home meal, snack, and bread in the intervention 1 group (protein group) or regular home meals in the intervention 2 group (regular group). Control group participants maintained their usual diet without a home meal service.

A total of 79 caregivers (49 females, 30 males, mean age 73.7 years) participated in the CareNutrition trial, and 69 completed the study. In the Power Meals trial, a total of 78 participants (47 females, 31 males, mean age 78.2 years) participated, and 67 completed the study. At baseline, 13–19% of caregivers, 26% of care recipients and 50% of home care clients had increased risk of malnutrition. Higher prevalence was observed among female caregivers, and among home care clients and care recipients. Good quality of life, better cognition, appetite, physical performance and greater hand grip strength, higher number of daily steps, and standing time were associated with better nutritional status, while depression symptoms, number of medication and higher risk of sarcopenia was associated with worse nutritional status. Mean protein intake was 1.0 g/kg aBW/d (Study I) and 0.90 g/kg aBW/d (Study III) calculated per body weight. Four out of five participants did not reach protein intake of ≥1.2 g/kg aBW/d, and there were lower intakes in energy and many nutrients compared to recommendations. Greater hand grip strength, better appetite and nutritional status, higher number of daily steps and daily MVPA time, greater standing time and higher number of warm meals were associated with higher protein intake, while higher risk of sarcopenia was associated with lower intake of protein. In the Care Nutrition trial, dietary guidance with group meetings seemed to increase protein intake by +0.10 g/kg aBW/d, although no significant difference emerged with the control group. In subgroup analyses, protein intake increased significantly among the males in the guidance group by 0.11 g/kg aBW/d and decreased among the control group by -0.07 g/kg aBW/d. In the Power Meals trial, the eight-week protein-rich home meal service in protein group increased protein intake by 0.11g/kg aBW/d and 9.4 g/d. It also increased calcium intake and seemed to improve the results in the Sit-to-Stand Test. Protein group and regular group increased saturated fat intake and decreased salt intake. There was no effect on overall quality of life.

In conclusion, the risk of malnutrition and low energy and protein intakes were common among older people living at home, and several factors were associated with them. Tailored dietary guidance including group meetings seemed to encourage older caregivers, especially males, to increase their protein intake. Protein-rich home meal service including snack and bread had more benefits for the nutrition and physical performance of older people than regular home meals.
TIIVISTELMÄ (FINNISH ABSTRACT)


Tämän väitöstyön tavoitteena oli 1) tutkia ikääntyneiden (≥65-vuotiaiden) omaishoitajien ja hoidon tarpeessa olevien ikääntyneiden (omaishoidottavat ja kotihoidon asiakkaita) ravitsemustilaa, ravintoaineiden saantia ja niihin yhteydessä olevia tekijöitä, 2) tutkia räätälöidyn yksilöllisen ja ryhmämuotoisen ravitsemusohjauksen vaikutusta (Care Nutrition-tutkimus 2016-2017) proteiinin saantiin omaishoitajien, erityisesti miesten, keskuudessa ja 3) tutkia kahden erilaisen kotieteriapalvelun (Power Meals-tutkimus 2018) vaikutusta proteiinin ja muiden ravintoaineiden saantiin, fyysiseen toimintakykyyn, ja elämänlaatuun omaishoitajien, omaishoidottavien ja kotihoidon asiakkaiden keskuudessa.

(tavanomainen ryhmä). Kontrolliryhmä noudatti omaa ruokavaliotaan ilman kotiateriapalvelua.

Care Nutrition-tutkimukseen osallistui 79 (keski-ikä 73.7 vuotta) omaishoitajaa (49 naista, 30 miestä), joista 69 suoritti tutkimuksen loppuun. Power Meals-tutkimukseen osallistui 78 (keski-ikä 78.2 vuotta) ikääntynytä (47 naista, 31 miestä), joista 67 suoritti tutkimuksen loppuun. Alkumittauksissa 13–19 %:lla omaishoidattavista, 26 %:lla omaishoidattavista ja 50 %:lla kotihoidon asiakkaista oli lisääntynyt aliravitsemuksen riski. Riski oli suurempi naispuolisilla omaishoitajilla sekä kotihoidon asiakkailla ja omaishoidattavilla. Hyvä elämislaatu, kognitio, ruokahalu, kädens puristusvoima ja fyysinen toimintakyky sekä korkeampi päivittäisten askelten ja seisomisen määrä yhdistettiin parempaan ravitsemustilaan, kun taas masennusoireet, korkeampi lääkkeiden määrä ja lisääntynyt sarkopenian riski olivat yhteydessä huoompaan ravitsemustilaan. Keskimääräinen proteiinin saanti oli kehon painoon suhteutettuna 1.0 g/kg aBW/pv (julkaisu I) ja 0.90 g/kg aBW/pv (julkaisu III). Jopa neljä viidestä sai suosituksesta (≥ 1.2 /kg BW/pv) vähemmän proteiinia. Myös energian ja muiden ravintolaineiden saannissa oli puutteita. Parempi kädens puristusvoima, ruokahalu ja ravitsemustila sekä korkeampi päivittäisten askelten ja seisomisen määrä, fyysinen aktiivisuus ja lämpimien aterioiden määrä olivat yhteydessä korkeampaan proteiinin saantiin, kun taas lisääntynyt sarkopenian riski oli yhteydessä alhaisempaan proteiinin saantiin. Care Nutrition-tutkimuksessa yksilöllinen ja ryhmämuotoinen ravitsemusohjauksesta riittää lisäävän proteiinin saantia +0.10 g/kg aBW/pv interventioryhmässä, vaikka kontrolliryhmän väliä ei ollut merkitseviä eroja. Alaryhmäanalyysissä proteiinin saanti kasvoi merkitysevästi miesten ja naisen oljauryhmän omaishoitajien keskuudessa 0.11 g/kg aBW/pv ja vähensi kontrolliryhmässä -0.07 g/kg aBW/pv. Power Meals-tutkimuksessa 8 viikon proteiinirikas kotiateriapalvelu välipaloilla ja leivillä (proteiinirhmä) lisäsi proteiinin saantia 0.11 g/kg aBW/pv ja 9.4 g/pv. Se lisäsi myös kalsiumin saantia ja näytti parantavan istumaanousustestin tuloksia proteiinirhmässä. Proteiinirhmä sekä tavanomainen ryhmä lisäisivät työntyteen rasvan saantia ja vähensivät suolan saantia. Kotiateriapalveluilla ei havaittu vaikutusta elämänlaatuun.

Yhteenvetona voidaan todeta, että aliravitsemuksen riski sekä alhainen energian ja proteiinin saanti olivat yleistä kotona asuville ikääntyneillä, ja useat eri tekijät olivat yhteydessä niihin. Ravitsemusohjauksa näytti rohkaiseman ikääntä omaishoitajaa lisäävän proteiininsaantian, erityisesti miesomaisihoitajien keskuudessa. Proteiinirikkaalla välipaloja ja leipää sisältävällä kotiateriapalvelulla oli enemmän hyötyjä ikääntyneiden ravitsemun ja fyysiseen toimintakykyyn verrattuna tavanomaiseen kotiateriapalveluun.
ACKNOWLEDGEMENTS

This doctoral dissertation was carried out at the Department of Food and Environmental Sciences, Faculty of Agriculture and Forestry, University of Helsinki, and in the Doctoral Programme in Population Health. The trials were conducted at Pori Social and Health Services, where I have had the pleasure to work during the past seven years. I am grateful for these instances for their support. My deepest gratitude goes to the older people who participated the trials and made this project possible.

I owe a debt gratitude to all those who contributed to this work. My deepest gratitude goes to my outstanding supervisors, Adjunct Professor Merja Suominen, Raisa Valve, PhD, and Maritta Salonoja, PhD. Thank you for your guidance, support, and encouragement in carrying out academic research. I have learned so much about older people’s nutrition, geriatrics, implementation of randomized controlled trials and writing articles. I have been truly fortunate to be supervised by experts in the field of nutrition and geriatrics. Thank you for sharing this journey with me.

I sincerely thank the personnel as well as my colleagues at Pori Social and Health Services who have contributed to completion of this work. I especially thank my dear friend Karoliina Salminen for great support, help and companionship over the years, and in the last meters of this dissertation. Karoliina has been the first one to call, whether it has been joy, crying or laughter - or all mixed together. Thank you Petra-Rautakallio for your input and work in the Power Meals study during my maternity leave and afterwards. Thank you Anna-Liisa Koivisto for being a best boss and a ”spare mom”, and always believing in me and my work. Thank you Marjut Länsiniemi and other work mates at Pori Social and Health Services for help and support. Our discussions and laughs during coffee breaks and lunches provided an enormous boost during this journey. Thank you Marika Laaksonen and Leila Fogelholm for pleasant collaboration during the Power Meals trial and for writing the articles. Thank you Hannu Kautiainen for professional help with statistical analyses. I also sincerely thank the members of my thesis committee, Professor Kaisu Pitkälä and Adjunct Professor Ulla Eloniemi-Sulkava.

My sincere thanks go to all valuable co-operation partners and funders. I thank National Institute for Health and Welfare (THL) in Finland for funding the Care Nutrition project. In the Care Nutrition trial we also had valuable co-operation partners such as the local Martha Organization, which organized the cooking classes – thank you for our pleasant co-operation. In the Power Meals trial, we had the pleasure to work with the funders Oy Karl Fazer Ab and
Compass Group FS. I am grateful for personal funding from the Finnish Cultural Foundation’s Satakunta Regional Fund and from the Satakunta Hospital District, Finland - my sincere thanks for the financial support.

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Finally, my heartfelt thanks go to my friends and family for their patience, love, and support. Having three wonderfull children in two years turned our world upside down, in a good way though. Still, the time to finish this dissertation has been challenging due enourmous sleep dept and lack of time. Without you all it would not have been possible. Thank you for keeping me sane and helping me balance work and family time during these years.

Kankaanpää, March 2022

Susanna Kunvik
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LIST OF ORIGINAL PUBLICATIONS

This doctoral dissertation is based on the following publications:


The publications are referred to in the text by their roman numerals. These publications have been reprinted with the permission of the copyright holders. In addition, some unpublished material is presented.
### ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>15D</td>
<td>15 D instrument measuring health-related quality of life</td>
</tr>
<tr>
<td>ADL</td>
<td>Activities of Daily Living</td>
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<tr>
<td>AUDIT</td>
<td>Alcohol Use Disorders Identification Test</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
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<tr>
<td>BW</td>
<td>Body weight</td>
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<tr>
<td>FFM</td>
<td>Fat free mass</td>
</tr>
<tr>
<td>FFQ</td>
<td>Food Frequency Questionnaire</td>
</tr>
<tr>
<td>g/kg aBW/d</td>
<td>grammes/adjusted body weight/day</td>
</tr>
<tr>
<td>GDS-15</td>
<td>Geriatric Depression Scale</td>
</tr>
<tr>
<td>HDM</td>
<td>Home-delivered meals</td>
</tr>
<tr>
<td>IADL</td>
<td>Instrumental Activities of Daily Living</td>
</tr>
<tr>
<td>MMSE</td>
<td>Mini Mental State Examination</td>
</tr>
<tr>
<td>MNA</td>
<td>Mini Nutritional Assessment</td>
</tr>
<tr>
<td>MVPD</td>
<td>moderate-to-vigorous physical activity</td>
</tr>
<tr>
<td>PP</td>
<td>Physical performance</td>
</tr>
<tr>
<td>PEM</td>
<td>Protein-energy malnutrition</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomized controlled trial</td>
</tr>
<tr>
<td>SARC-F</td>
<td>Simple Questionnaire to Rapidly Diagnose Sarcopenia</td>
</tr>
<tr>
<td>SNAQ</td>
<td>Simplified Nutritional Assessment Questionnaire</td>
</tr>
<tr>
<td>SPPB</td>
<td>Short Physical Performance Battery</td>
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</table>
1 INTRODUCTION

The global population aged 65 years and over is growing faster than all other age groups. By 2050, one in six people (16%) in the world will be over the age of 65, up from one in 11 (9%) in 2019 (United Nations 2019). In Finland, the number of people aged 65 years and older was 22% in 2019, and this figure is expected to further increase to 28% by 2050. This demographic shift is progressing so quickly, that Finland is ranked among the five fastest ageing populations worldwide (United Nations 2019).

As a consequence of the extended life expectancy, the number of older people with disabilities and chronic diseases who need support and assistance at home is on the rise (Abdi et al. 2019, Cès et al. 2019). The provision of care to people who suffer from chronic diseases involves healthcare services, and other sources of long-term care such as informal caregiving provided by family member or another close person (Oliva-Moreno et al. 2015). In Finland, about 6% (67 700) individuals aged ≥65 years received professional home care and around 3% (33 500) informal care in 2018. Also, the number of older informal caregivers was large, as 27 600 older (≥65 years) caregivers helped their relatives or loved ones (Sotkanet 2020). Prevention, supportive services and care are needed to improve the health and well-being of all older people living at home.

Adequate nutrition is important in maintaining good health, well-being, physical performance and quality of life among older people (Volkert et al. 2019, Clegg & Williams 2018, Péter et al. 2014, Morley 2012, Anderson et al. 2011, Visvanathan & Chapman 2010). Unfortunately, ageing increases the risk of malnutrition, defined as deficiencies, excesses, or imbalances in a person’s intake of energy and/or nutrients (World health organization 2021). The increased risk may be due to many different factors, including physiological changes, social and environmental influences, decreased physical functioning, cognitive decline, and multimorbidities (Norman et al. 2021, Volkert et al. 2019, Morley 2012). Therefore, poor nutrition, even in developed settings, is common (Robinson 2018). Globally, around one-third of community-dwelling older people have impaired nutritional status (Cereda et al. 2016) and insufficient energy and nutrient intake such as low protein intake (Hengeveld et al. 2020, Hengeveld et al. 2018, Yannakoulia et al. 2018). These people are more likely to have poorer health outcomes, longer hospital stays and increased mortality (Robinson 2018).

To optimally prevent and treat malnutrition in older people, effective and evidence-based nutritional interventions should be identified and offered (Volkert et al. 2020). Dietary guidance is considered to be effective in the
management of numerous diseases, improving well-being, health and nutrition among older people (Volkert et al. 2019, Vasiloglou et al. 2019, Baldwin & Weekes 2012). Receiving home-delivered meals may contribute to the health and independence of older people living at home, especially those who are food insecure (Campbell et al. 2015). It also may improve nutritional status and nutrient intake such as energy and protein intakes (Fleury et al. 2021, Walton et al. 2020, IJmker-Hemink et al. 2020, Zhu & Ann 2013).

Several studies have examined the prevalence of malnutrition in community-dwelling older people, but fewer studies have explored the nutrient intakes in this population. Also, different interventions to improve nutritional status or nutrient intakes have been performed, but most of them are performed in hospital or long-term care settings (Rea et al. 2019, Nykänen et al. 2014). More randomized controlled trials are needed to identify effective ways to improve the nutrition of older people living at home.

The aim of this doctoral dissertation was 1) to investigate nutritional status, nutrient intake and factors associated with these among older (≥65 years) community-dwelling (living at home) caregivers and people receiving care (care recipients of the caregiver and home care clients), 2) to assess the effectiveness of tailored dietary guidance with group meetings (Care Nutrition trial) on protein intake among older caregivers, especially males, and 3) to evaluate the effectiveness of two different 8-week home-meal services (Power Meals trial) in intake of protein and other nutrients, physical performance, and quality of life among older community-dwelling caregivers and people receiving care.
2 REVIEW OF THE LITERATURE

2.1 Nutrition in older age

The goal of healthy ageing is not only to increase the years of life but also to extend healthy active years. Adequate nutrition is fundamental to good health and quality of life at all stages of the life span (Norman et al. 2021, Wickramasinghe et al. 2020). It plays an important role in the prevention of chronic diseases and memory disorders (Wickramasinghe et al. 2020, Volkert et al. 2019). Particularly among older people, good nutrition is an important modulator of health and well-being (Wickramasinghe et al. 2020, Volkert et al. 2019). In this doctoral dissertation the term ”older people” refers to the people aged ≥65 years.

Older people form a heterogeneous group with different needs related to multimorbidity, frailty, and increased risk of functional impairment. In nutrition, it is more appropriate to assess older people according to their state of health and functional capacity rather than their chronological age (Figure 1). Ageing and the prevalence of various diseases set special requirements for maintaining good nutrition (Wickramasinghe et al. 2020, Corish & Bardon 2019, John et al. 2013). The aetiology of malnutrition risk among community-dwelling (living at home) older people differs from hospitalized older people or the elderly receiving long-term residential care (Corish & Bardon 2019). The heterogeneity of older people stands out particularly in the community-setting; while some older people live vibrant and active lives, others are in poor condition, needing daily support. Some prepare their own food and have a good appetite, while others rely on meal services and may eat very little. The prevalence of nutritional problems is directly correlated with the level of dependence (Cereda et al. 2016).

Improvements in nutrition are known to bring benefits to older people and many diseases and conditions related to older age can be prevented, modulated or improved by good nutrition (Clegg 2018). Good nutritional status and sufficient nutrient intake can prevent frailty and sarcopenia (Cruz-Jentoft et al. 2017, Morley et al. 2010), maintain immune functioning, support cognition, promote recovery and rehabilitation, and maintain good physical performance (Ni Lochlainn et al. 2021, Volkert et al. 2019, Bauer et al. 2013). Sufficient protein intake reduces age-related muscle mass loss and improves physical function (Nowson & O’Connell 2015, Deutz et al. 2014, Bauer et al. 2013). Dietary habits consistent with the guidelines have been associated with quality of life and survival in older adults (Anderson et al. 2011).
As part of primary care, nutrition screening, dietary assessment, and individualized nutritional care are important factors in treatment and prevention of diseases (Volkert et al. 2019). All older people should have the right to good nutrition regardless of disease or limitations related to functional capacity or cognition (National Nutrition Council and Finnish Institute for Health and Welfare 2020). In Finland, the latest Food Recommendation for Older Adults are published 2020, and the publication is intended to serve as a national quality recommendation for all operators providing food services or social and health care (National Nutrition Council and Finnish Institute for Health and Welfare 2020).

Practical and realistic approaches are required to improve the nutrition, diet and food intake among older people (Clegg & Williams 2018). A wide range of dietary interventions has shown to improve a number of anthropometric, nutritional and functional indices in the elderly (Poscia et al. 2018). Dietary guidance and education in preparing food have been shown to be effective in improving well-being, health, and nutrient intake among older people (Clegg & Williams 2018, Zhou et al. 2018, Baldwin & Weekes 2012). Health-care experts should guide older people and promote healthy diets, paying particular attention to adequate energy, and protein intake (Yannakoulia et al. 2018). Also, informal caregivers should be offered nutritional education and individualized dietary guidance to ensure basic knowledge of nutrition and to promote adequate dietary intake (Volkert et al. 2019). Encouraging older people to prepare meals (Clegg & Williams 2018) and providing opportunities to eat in the company of others are simple strategies to increase food intake and appetite (Volkert et al. 2019, Clegg & Williams 2018). Also, receiving home-delivered meals has been associated with improvements to the nutrition, health and independence of older people living at home (Zhou et al. 2018, Campbell et al. 2015). In Finland, there are several home-delivered meal service providers, mostly municipal (Jämsén 2018). Several solutions are needed to develop these services, since the need for home-delivered meal services will clearly increase in the future as the number of older people will increase and in addition, customers will be increasingly in poorer condition (Jämsén 2018).
2.1.1 Factors related to nutritional problems

Malnutrition, e.g. undernutrition, is defined as a state of nutrition in which a deficiency or excess/imbalance of energy, protein and other nutrients may cause altered body composition, diminished physical and mental function and adverse clinical outcomes (Cederholm et al. 2019, Stratton et al 2003). Due to the frequently insufficient protein and energy intake, it is therefore also commonly referred to as protein-energy malnutrition (Norman et al. 2021).

Increasing age brings many changes that increase the risk of malnutrition due to multiple nutritional, physiological and psychological reasons (Wickramasinghe et al. 2020, Volkert et al. 2019, Clegg & Williams 2018). In addition to insufficient nutrient intake, there is growing appreciation that malnutrition may occur because of disease-associated inflammatory or other mechanisms (Cederholm et al. 2019). As the level of dependence increases due to health problems or social changes, the prevalence of nutritional problems rises. However, the aetiology of malnutrition is complex and multifactorial (Norman et al. 2021). During the last decades, malnutrition has received increasing scientific attention and is now regarded as a major geriatric syndrome characterized by multifactorial causality (Volkert 2013). The nutritional risks from different aspects of ageing are presented in next sections and in Table 1.
<table>
<thead>
<tr>
<th>Table 1. Risk factors for malnutrition among older people</th>
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<tbody>
<tr>
<td><strong>Demographic</strong></td>
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<tr>
<td>Increasing age</td>
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<tr>
<td>Low income/educational level</td>
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<tr>
<td>Female gender</td>
</tr>
<tr>
<td>Living alone, widowed, divorced, separated or single</td>
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<tr>
<td>Being male a caregiver</td>
</tr>
<tr>
<td><strong>Nutritional</strong></td>
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<tr>
<td>Poor appetite, food intake and diet quality</td>
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<tr>
<td>Food avoidance</td>
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<tr>
<td>Eating alone</td>
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<tr>
<td>Finding meal preparation to be a challenge</td>
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<tr>
<td>Changing nutritional requirements</td>
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<tr>
<td><strong>Disease and care</strong></td>
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<tr>
<td>Hospitalization</td>
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<tr>
<td>Diseases and multimorbidity, untreated pain</td>
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<td>Poor self-reported health</td>
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<td>Polypharmacy</td>
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<tr>
<td>Restrictive therapeutic diets</td>
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<tr>
<td><strong>Physiological</strong></td>
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<tr>
<td>Changes in the gastrointestinal tract</td>
</tr>
<tr>
<td>Impairment of hunger, thirst, and taste</td>
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<tr>
<td>Oral and dental problems, dysphagia</td>
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<tr>
<td>Changes in body composition, lower BMI/body weight</td>
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<tr>
<td><strong>Physical function</strong></td>
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<tr>
<td>Poor physical function and inactivity</td>
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<tr>
<td>Frailty and mobility disorders</td>
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<tr>
<td>Eating dependency</td>
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<tr>
<td><strong>Psychosocial</strong></td>
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<tr>
<td>Dementia / cognitive decline</td>
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<tr>
<td>Loss of interest in life, quality of life</td>
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<tr>
<td>Loneliness and social isolation</td>
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<tr>
<td>Depression and other mental conditions</td>
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<td>Alcohol abuse</td>
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**Demographic risk factors**

According to a large systematic review and meta-analysis, malnutrition risk is associated with older age, being higher in the older elderly (>80 years) than in the younger elderly (Leij-Halfwerk 2019). The risk is consistent across settings, and independent of the screening tool used (Leij-Halfwerk 2019). Another review highlighted that age per se is better at predicting adverse outcomes than any malnutrition screening tool (Elia & Stratton 2012).

In the systematic review and meta-analysis of Crichton et al. (2019), the authors found that globally, females had 45% greater odds of being malnourished than males. Also, low socioeconomic status (O’Keeffe et al. 2019), poverty (Volkert et al. 2020), and low education (Poggioigalle et al. 2021, Besora-Moreno et al. 2020) have been shown to increase the risk of malnutrition. Changing family dynamics means that older adults have less support, while facing substantial challenges in obtaining good nutrition (Shlisky et al. 2017). In a systematic review of 39 studies, family structure and living situation were consistently associated with dietary patterns (Poggioigalle et al. 2021). Living alone is associated with decreased appetite (Landi et al. 2016) and risk of malnutrition (Roberts et al. 2021, Besora-Moreno et al. 2020). In a recent systematic review and meta-analysis, several factors related
to marital status, namely being a widow, divorced, separated, or single were shown to increase the risk of malnutrition (Besora-Moreno et al. 2020).

Being a caregiver brings new challenges to everyday life in the form of food worries and potential lack of cooking experience (Fjellström et al. 2010). A gender difference exists in the ability to cope with nutrition-related caregiver responsibilities, with male caregivers having an increased risk of insufficient energy and protein intake and insecurity as a food provider (Puranen et a. 2014, Fjellström et al. 2010). There is a need for tailored dietary guidance among older individuals, and especially among male caregivers (Puranen et al. 2014).

**Nutritional risk factors**

With declining activity levels and physical and psychological factors, age-related falls in food consumption are expected in later life. The differences in energy intake through the lifespan are significant. In a meta-analysis of energy intake data from healthy older (~70 years) and younger (~26 years) adults, a difference in energy intake of approximately 16-20% was shown between the groups (Giezenaar et al. 2016). Hunger was 25-39% lower, and fullness 37% higher in older than in younger adults (Giezenaar et al. 2016). Also, older people usually eat more slowly, consume smaller meals and snack less, leading to lower food consumption and to weight loss (Shlisky et al. 2017, Giezenaar et al. 2016).

The combination is challenging, since older people need even more nutrient-dense foods to meet their requirements. For community-dwelling older people, the inadequate intake of nutrient-dense foods is the main mechanism for nutritional problems (Agarwal et al. 2013, Keller 2007). Age-related inefficiencies in absorption and utilization mean that the requirement for some important nutrients increases, despite lower energy needs (Shlisky et al. 2017). For example, older people need more dietary protein than younger adults to support good health (Bauer et al. 2013). When protein intake is low, the risk of impaired physical function (Mendonça et al. 2021) and developing sarcopenia (Wickramasinghe et al. 2020, Morley et al. 2010) increases. Higher dietary protein intake among older people is beneficial to support good health, promote recovery from illness and maintain functionality (Mendonça et al. 2021, Deutz et al. 2014, Bauer et al. 2013). It also lowers the risk of frailty, losing weight and slows the decline of muscle mass (Mendonça et al. 2021, Lorenzo-López et al. 2017, Deutz et al. 2014, Bauer et al. 2013).

Anorexia of ageing is a notable paradigm of geriatric syndromes, defined as the loss of appetite and/or decreased food intake in late life. It is associated with many of the syndromes and effects that may occur when health impairments combine to make older people more vulnerable to both external and internal stressors (Landi et al. 2016).
Eating dependency (O’Keeffe et al. 2019), poor appetite and difficulties in buying or preparing food have been found to be risk factors for malnutrition (O’Keeffe et al. 2019, FavarO-Moreira et al. 2016). Recent changes in lifestyle and the environment make adherence to dietary recommendations challenging for many older people (Shlisky et al. 2017) and the lack of dietary advice and education shows a correlation with malnutrition (O’Keeffe et al. 2019).

**Risk factors related to disease and care**
Malnutrition risk is associated with the presence of disease and institutionalization (Leij-Halfwerk 2019, FavarO-Moreira et al. 2016) and hospitalization (O’Keeffe et al. 2019), meaning that malnutrition and its risk are directly associated with the level of dependence (Cereda et al. 2016). Particularly in case of acute and chronic illness nutritional problems are common, and a reduced dietary intake in combination with catabolic disease can quickly lead to malnutrition (Volkert et al. 2019), disease-related loss of weight, loss of muscle mass and strength and finally, the frailty syndrome (Norman et al. 2021). An imbalance between nutrient intake and requirements may develop when nutritional needs increase as a consequence of acute or chronic disease (Volkert et al. 2020). Energy, protein and other nutrients are needed to promote recovery from illness and maintain functionality (Bauer et al. 2013).

The use of pharmacologic treatment becomes more common with aging, and the extent of medication intake is a factor that influences, either directly or indirectly, the risk of malnutrition (Volkert et al. 2020, O’Keeffe et al. 2019, FavarO-Moreira et al. 2016). Medications can cause loss of appetite, nausea, diarrhea, change in weight, taste alterations, hyposalivation, and changes in electrolyte balance, lipid profile and glucose metabolism (John et al. 2013).

**Physiological risk factors**
Several changes in body composition after the age of 60 years may occur (Wickramasinghe et al. 2020, Landi et al. 2016). Progressive decrease in body weight may result from a decrease in lean mass with an increase in fat mass. Even with stable body weight, age-related changes in body composition can occur. This may result in impaired physical function and higher dependency in activities of daily living (Wickramasinghe et al. 2020, Cereda et al. 2016).

Protein-energy malnutrition (PEM) is often observed state among older people (Leij-Halfwerk et al. 2019, Sieber 2019). PEM is a consequence of insufficient intake and/or absorption of protein, energy, and other nutrients and together with other predisposing factors leads to sarcopenia, a condition where age-related loss of muscle mass, decreased strength, osteoporosis and
impaired immunity can occur (Wickramasinghe et al. 2020, Sieber 2019, Morley et al. 2010).

Poor oral health, several changes in the mouth and difficulties in chewing and swallowing may limit the type and quantity of food consumed and lead to poor nutrition (O’Keeffe et al. 2019, Fávaro-Moreira et al. 2016, Landi et al. 2016, Baijens et al. 2016, Mann et al. 2013). Changes in digestive hormones and gastrointestinal function can result in early satiation, decrease of appetite and reduced digestive ability (Landi et al. 2016). Gastrointestinal diseases, malabsorption and acute and chronic infections often cause micronutrient deficiencies, because of increased energy requirements (Landi et al. 2016).

Sensory impairments, such as decreased vision and hearing (O’Keeffe et al. 2019, Landi et al. 2016) and impaired sense of taste and smell can affect appetite and food intake (Wickramasinghe et al. 2020, Landi et al. 2016). This contributes to impaired food intake and typically has a negative impact on the type of food ingested, resulting in a less varied diet (Landi et al. 2016).

**Physical functioning risk factors**
Low physical activity and general health decline, including impairments in physical function, are known to be significant risk factors for malnutrition (Volkert et al. 2020, Fávaro-Moreira et al. 2016). The gradual deterioration of body function and health status, also known as frailty, is suggested to be an important determinant of malnutrition among older people (Fávaro-Moreira et al. 2016). Functional impairments in the basic and instrumental activities of daily living are related to loss of appetite and reduced food intake (Landi et al. 2016). Changes in physical functioning cause mobility limitations, which increase the risk for malnutrition by causing problems in eating, getting groceries, or preparing foods (Landi et al. 2016).

**Psychosocial risk factors**
Various nutritional problems may occur when the cognition declines leading to reduced dietary intake, malnutrition, and other nutritional challenges (O’Keeffe et al. 2019, Fávaro-Moreira et al. 2016, Volkert et al. 2015). Also, loneliness, depression, loss of interest in life, poor self-reported health status and alcohol consumption have been observed to be significant risk factors for malnutrition (Volkert et al. 2020, O’Keeffe et al. 2019, Fávaro-Moreira et al. 2016, John et al. 2013, van Bokhorst-de van der Schueren 2013). These factors are often associated with loss of appetite (Landi et al. 2016). Older people with malnutrition are more likely to experience poor quality of life (Agarwal et al. 2013, Rasheed & Woods 2013) and better nutritional status has been associated with less problems in health-related quality of life (HRQL) (Kostka et al. 2014).
2.1.2 Methods of screening and assessing nutritional status

Nutritional screening and assessment are regarded as important components of multi-dimensional evaluation of older people (Cereda et al. 2016). Early detection and effective treatment can reduce the development of nutritional problems and the associated negative health effects (Volkert et al. 2020). The terms screening and assessment are often used interchangeably, but in fact screening determines the risk of a problem and assessment determines the presence of a problem (Guyonnet & Rolland 2015). Nutritional screening tools are useful for early and rapid identification of malnutrition but need to be used with nutritional assessment for accurate malnutrition identification (Dent et al. 2019).

Several screening tools are available, but they perform differently in terms of sensitivity and specificity and in assessing nutritional status (Cereda et al. 2016). There has also been a lack of consensus on diagnostic criteria in clinical settings. No single approach to diagnose malnutrition has reached a broad global acceptance (Cederholm et al. 2019).

The Global Leadership Initiative on Malnutrition (GLIM) has published a global consensus on the identification and endorsement of criteria for the diagnosis of malnutrition in clinical settings (Cederholm et al. 2019). This two-step approach for diagnosing malnutrition includes 1) screening with validated method to identify persons at risk of malnutrition and 2) grading the severity of malnutrition (Cederholm et al. 2019). The approach recommends classifying malnutrition into four aetiology-related diagnosis categories (Cederholm et al. 2019). The European Society for Clinical Nutrition and Metabolism (ESPEN) guidelines recommend that all older persons should be routinely and systematically screened for malnutrition with a validated measure in order to identify those with (risk of) malnutrition, independent of specific diagnosis or overweight (Volkert et al. 2019). The most common validated screening tool for older persons is the Mini Nutritional Assessment (MNA), which includes a short form (MNA-SF) and the complete assessment (full MNA) (Volkert et al. 2019, Vellas et al. 1999). It has been designed and validated to provide a single, rapid assessment of nutritional status among older people in different settings (Guigoz et al. 2002, Vellas et al. 1999).

The MNA-SF was developed and validated as a screening process that includes the standard screening parameters (body mass index, weight loss, reduced intake, disease) and two important geriatric syndromes that contributes to the development of malnutrition; immobility and neuropsychological problems (Guigoz et al. 2002). The full MNA comprises a two-step procedure: nutritional screening and an assessment. It consists of 18 items grouped in four sections: anthropometric assessment (weight, height, weight loss), general assessment (lifestyle, medication use, mobility), dietary assessment
(number of meals, food and fluid intake, autonomy of feeding), and subjective assessment (self-perception of health and nutrition status). The MNA is easy, sensitive (96%), specific (98%), and accurate in identifying nutrition risk (Guigoz et al. 2002). But even with good sensitivity, MNA does not necessarily identify all those with poor nutrient intakes who may be at risk of developing malnutrition (Jyväkorpi et al. 2016). In Finnish study combining data of 900 older people, a high proportion of older people with normal nutritional status according to MNA nevertheless had poor energy and protein intakes (Jyväkorpi et al. 2016).

Several other nutrition screening tools specific to older people have been developed. The most well-known and popular are MST, MUST, NRS 2002, SGA, and SNAQ (Guyonnet & Rolland 2015). Their characteristics are presented in more detail in following Table 2. Of all existing malnutrition screening tools worldwide, 34 have been validated for use in older people, and 20 of these are validated in the community setting (Power et al. 2019, Power et al. 2018).

Albumin and prealbumin are commonly used laboratory markers to assess nutritional status (John et al. 2013) and severity of malnutrition (Vellas et al. 2006). However, they may be affected by confounders such as ongoing inflammation, renal failure, or impaired hepatic function (John et al. 2013). Haemoglobin, vitamin D levels, cholesterol levels, insulin-like growth factor, and total lymphocyte count have been used (John et al. 2013). While some experts consider nutritional laboratory markers to be unreliable and time-consuming measures of malnutrition (Power et al. 2018), they are nonetheless frequently used.
Table 2. Nutritional status screening and assessment methods among older people

<table>
<thead>
<tr>
<th>Type of tool</th>
<th>Method</th>
<th>Target population</th>
<th>Strengths</th>
<th>Limitations</th>
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<tr>
<td>Screening tools</td>
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</table>
| Mini Nutritional Assessment Short Form (MNA-SF) | Consists of 6 questions that have high correlations with the original 18-item long form | Developed for use in older people in all settings                                     | - Easy and quick  
- Validated in all settings; good sensitivity and specificity in the community setting  
- Widespread  
- Respondent-friendly                                                                 | - Can over-diagnose risk of malnutrition in frail, older people  
- Usually validated against Full MNA so incorporation bias is present  
- Inability to be used in patients with cognitive impairment  
- Requires weight which may be complicated to measure |
| Malnutrition Screening Tool (MST)   | Consist of 3 questions related to recent unintentional weight loss and eating poorly because of a decreased appetite | Was not designed for older adults, but has been widely validated in hospitalised older patients | - Easy and quick  
- Appropriate tool for use in hospitalized older patients                                                                 | - No studies have assessed validity in community-dwelling older people  
- Focuses only on unintended weight loss and appetite |
| Malnutrition Universal Screening Tool (MUST) | Consists of body mass index, a weight loss category, and an acute disease score | Developed for use in community settings and then extended to other healthcare settings. Developed for general adult population, but is used among older people | - Can be used across settings  
- Reliable  
- Quick  
- Require less subjectivity by interviewers  
- One validation study in community-dwelling setting older people reported good sensitivity (100%) and specificity (98%) when validated against clinical assessment by a trained dietitian | - Less clinically applicable in than other screening tools  
- Its use in older adults across all settings remains uncertain  
- Low BMI limits  
- Recent food intake is not included  
- Calculations (weight loss %) takes time  
- Not sensitive for older people |
| Nutritional Risk Screening 2002 (NRS-2002) | Consists of 4 questions concerning BMI, loss of body weight, decreased dietary intake and critical illness | Developed and promoted for use in adults in the hospital setting. May be used among older people | - Easy to use  
- Considers disease severity  
- Good predictive validity  
- Well validated  
- Considers disease severity                                                                 | - May not be used outside the hospital  
- May overestimate risk of malnutrition  
- Low BMI limits  
- Designed for adult population generally |
<table>
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<tr>
<th>Type of tool</th>
<th>Method</th>
<th>Target population</th>
<th>Strengths</th>
<th>Limitations</th>
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</table>
| Simplified Nutritional Assessment Questionnaire   | Consisting of 4 items; appetite, early satiety, food taste, and number of meals | Developed for community-dwelling and long-term-care residents | - Quick and easy to implement  
- Requires no specialist equipment or training of assessors  
- Validated in community-dwelling adults | - More work is needed to validate the SNAQ, particularly against components of nutritional assessment |

**Assessment tools**

| Mini Nutritional Assessment, Full Form (MNA-FF) | Consists of 18 items related to anthropometric assessment, general assessment, dietary assessment, subjective assessment | Developed for use in older people in all settings | - Includes assessment  
- Easy to use  
- Widespread  
- Respondent-friendly  
- Highly sensitive, specific, accurate  
- Has undergone extensive validity and reliability testing, particularly in community-based studies | - Full MNA takes time  
- Calf and arm circumference needed  
- Requires weight which may be complicated to measure  
- Can over-diagnose risk of malnutrition in frail, older people  
- Inability to be used in patients with cognitive impairment  
- Disease severity not considered |

| Subjective Global Assessment (SGA)               | Consists of three components; weight changes, nutrient intake assessment, GI symptoms, assessment of subcutaneous fat, muscle wasting and ankle/sacral oedema | Developed for surgical population | - Assessment tool  
- Valid and reliable  
- Easy to use | - Has no numerical scoring  
- Not objective like the MNA  
- Impractical for intervention and follow-up studies  
- Construct and concurrent validity are low |

2.1.3 Nutritional status among older community-dwelling people

The prevalence of malnutrition and the risk of malnutrition differ significantly across different settings, being lowest among community dwellers and highest in long-term and rehabilitation care institutions (Leij-Halfwerk et al. 2019). In a Finnish study of 400 community-dwelling older (≥ 75 years) people with history of vascular disease, 8% were found to be malnourished and 86% were at risk of malnutrition according to MNA (Soini et al. 2011). In international systematic review and meta-analysis, the prevalence of malnutrition in community-dwelling older people was found to be 3% and the risk of malnutrition 27% according to MNA (Cereda et al. 2016). Among out-patients, the prevalence of malnutrition was 6% and the risk of malnutrition 31%, and among home-care clients 9% and 48% respectively (Cereda et al. 2016). The results are similar to the review of Guigoz (2006), showing the malnutrition prevalence to be 2% and the risk of malnutrition 24% among older people in the community, using MNA. Even though the highest prevalence of malnutrition is found in older people in the rehabilitation setting, the older people living at home quantitatively constitute the majority, as most older people live on their own up to a very high age (Cereda et al. 2016, Kaiser et al. 2009).

In the large systematic review and meta-analysis of Leij-Halfwerk et al. (2019), they studied the prevalence of PEM risk among older adults in 24 European countries with 22 different malnutrition screening tools. The pooled prevalence rates of high malnutrition risk across all malnutrition screening tools and countries was 9% in the community settings, 19 studies out of 32 of which were carried out with MNA-SF (Leij-Halfwerk et al. 2019). Another systematic review, meta-analysis and meta-regression investigating the prevalence of PEM reported it to be between 33% and 17% among European community-dwelling older people using different methods such as MNA and SGA (Crichton et al. 2019).

Older caregivers are known to have nutritional problems. One out of five is reported to suffer from low appetite and malnutrition risk (Torres et al. 2010). Rullier et al. (2013) examined the nutritional status of older caregivers and care recipients with dementia. One third of the caregivers (32%) were at risk of malnutrition and 5% had poor nutritional status. Among the care recipients, 59% were at risk of malnutrition and 23% had poor nutritional status (Rullier et al. 2013). Tombini et al. (2016), reported an even higher prevalence, as malnutrition was found among 23% of older caregivers and its risk was 41%. Also, 95% of the care recipients were malnourished or at risk of malnutrition, mostly since they all suffered of Alzheimer’s disease (Tombini et al. 2016). In
of home care clients were at risk of malnutrition or were malnourished (Kaipainen et al. 2015).

2.1.4 Dietary assessment methods

Different methods have been developed to assess the intake of food, which is analysed to show the participant’s nutrient intake from a prospective or retrospective as well as a subjective or objective point of view. In the community setting, self-reported dietary intake can be assessed by methods of prospective real-time recording with food records (i.e. food diary). Methods of retrospective recall are 24-hour dietary recall, food frequency questionnaire (FFQ) and dietary history (Bailey 2021, Shim et al. 2014). In these methods, data are collected from the subjective point of view, with or without the help of a trained interviewer (Shim et al. 2014).

The choice of an adequate dietary assessment method depends on the research question, study design, sample characteristics and size, such as age group, and the foods and nutrients being evaluated (Bailey 2021, Straßburg et al. 2019). Recall methods are frequently used in nutritional epidemiological investigations and food records and recalls in randomized controlled trials and cohorts (Shim et al. 2014). The characteristics of the different methods are presented in more detail in Table 3.

Food records are considered to be easily applied to diverse groups with different eating habits and may be used to estimate the average intake of a certain population (Shim et al. 2014). The food record includes a detailed listing of all foods consumed on one or more days (Baranowski 2013). The chosen time-period should include one weekend day since food consumption differs between weekdays and weekends (Straßburg et al. 2019). Usually 3–4 days of intake are recorded, since participant burden can cause a decline in the quality of information recorded if more days are recorded (Bailey 2021). The method does not depend on memory (Straßburg et al. 2019), and the open-ended structure of the food diary and questions yields abundant information that can be analysed from various perspectives (Shim et al. 2014).

The accuracy of the food records differs since food records can be filled out with actual (weighed) or estimated measurements. In the weighed food record, foods and beverages are weighed at the time of consumption, therefore providing accurate information on portion sizes. In European countries where foods are typically quantified by gram weight, weighed records are common (Baranowski 2013). In estimated food records, the portion sizes are estimated. Food records can be a combination of both methods. Instructions should be provided to guide participants in recording the appropriate level of food
description detail (Baranowski 2013). This increases the accuracy of reporting (Bailey 2021).

Food records are considered to be a good method for evaluating dietary intake among older people (Thompson & Byers 1994). They have been shown to adequately represent the dietary intake in the community setting (Engelheart & Akner 2015, Gariballa & Forster 2008). Even though older people may have some difficulties with keeping records and estimating portion sizes at home, the estimated food records have been highly correlated with weighed intakes in controlled settings such as hospitals (Gariballa & Forster 2008).

All dietary assessment methods have strengths and limitations. Determining what people actually eat is problematic. Even when the best possible method or combination of different methods is selected, measurement bias is possible and must be taken into account in the analysis and results (Freedman et al. 2011). The most common problems in these methods are over- or under-reporting of the foods consumed because of participants’ inability to fully and accurately remember or report their intakes (Bailey 2021). There can be intentional misreporting of the consumption of certain foods (Naska et al. 2017), since respondents may improve their dietary habits unintentionally through self-reflection (Straßburg et al. 2019, Shim et al. 2014). Social desirability can cause a general tendency to over-report foods that are considered healthy and under-report foods that are considered less healthy (Bailey 2021). In one study, 30% of older (70–96 years) participants were identified as under-reporters with three-day food records (Soriano et al. 2018).

Also, there can be limitations in the food composition databases applied to convert the reported food consumption to energy and nutrient intakes (Naska et al. 2017). In open-ended questionnaires and food records, much effort is needed to collect and analyse the data. Questionnaires require careful review by the researchers to ensure that all reported data are included (Shim et al. 2014). These processes tend to be laborious, time-consuming and expensive to implement (Shim et al. 2014).
<table>
<thead>
<tr>
<th>Method</th>
<th>Data collected</th>
<th>Strengths</th>
<th>Limitations</th>
</tr>
</thead>
</table>
| Food record             | Actual intake information over a previously specified period of time, using subjective measure with food diary and open-ended, self-administered questionnaires | - Detailed intake data  
- No interviewer required  
- No recall bias  
- Works with older people, since they have quite stable food habits  
- Used in RCTs | - Large respondent burden  
- Good literacy skills and accuracy needed  
- Respondents must be trained before participating  
- High motivation necessary  
- Possible under- or overreporting  
- Can influence food behavior in respondents  
- Time-consuming to analyse  
- Multiple days required to assess usual intake |
| 24 h dietary recall     | Actual intake information from the last 24 hours using subjective measure with open-ended questionnaires administered by a trained interviewer | - Provides detailed intake data  
- Relatively small respondent burden  
- Literacy skills not required  
- Used in national surveys | - Possible recall or interviewer bias  
- Trained interviewer required  
- Expensive and time-consuming  
- May not provide information on usual intake  
- Does not show rarely eaten foods |
| Food frequency questionnaire | Usual intake estimates over a longer period (6–12 months) using subjective measure with a predefined, self- or interviewer administered format | - Assesses usual dietary intake simply  
- Cost-effective  
- Time-saving | - Specific to study groups and research aims  
- Low accuracy  
- Recall bias  
- Requires accurate analysing of developed questionnaires |
| Dietary history         | Usual intake estimates over a longer period using subjective measures with open- and closed-ended questionnaires administered by a trained interviewer | - Assesses usual dietary intake  
- Literacy skills not required  
- Relatively small respondent burden | - Time-consuming  
- Expensive  
- Possible recall or interviewer bias  
- Trained interviewer required |

2.1.5 Nutrient and energy intakes among older community-dwelling people

Energy
The recommendation for sufficient energy intake among older people varies. The Nordic Nutrition Recommendation states the recommendation to be ≥1700 kcal/d among females and ≥2050 kcal/d among males aged 61–74 years (Nordic Council of Ministers 2012). Lowenstein (1982) suggested a reference value of 1500 kcal/d as the minimum daily energy intake necessary to provide an adequate intake of micronutrients from a regular diet. The Finnish food recommendation for older adults also considers intake below 1500 kcal/d to be very low, usually indicating low physical activity or low body weight (National Nutrition Council and Finnish Institute for Health and Welfare 2020).

In the ten original studies in Table 4 (Koponen et al. 2021, Kehoe et al. 2021, Hengeveld et al. 2018, Valsta et al. 2018, Fernandez-Barres et al. 2016, Xu et al. 2015, Jyväkorpi et al. 2015, Power et al. 2014, Geirsdottir et al. 2013, Tieland et al. 2012), the mean energy intake of older community-dwelling people varie from 1313 kcal/d to 2245 kcal/d, being lowest among Finnish females receiving care from caregiver (Jyväkorpi et al. 2015) and highest among community-dwelling Dutch males aged 65 – 74 years (Tieland et al. 2012). The energy intake were higher among males than females (Xu et al. 2015, Jyväkorpi et al. 2015, Power et al. 2014, Geirsdottir et al. 2013, Tieland et al. 2012) and lower among older old than younger old (Tieland et al. 2012). In the National FinDiet Survey, the mean energy intake of Finnish males (n=204) and females (n=247) aged 65–74 years was 1906 kcal/d and 1586 kcal/d respectively (Valsta et al. 2018).

In the systematic review of Ter Borg et al. (2015), the authors reported a comprehensive overview of the energy and macronutrient intakes of community-dwelling older (≥ 60 years) people from an international comparison of 46 studies. The energy intakes were below the recommendations, using the FAO/WHO (Food and Agriculture Organization of the United Nations /World Health Organization) reference values of 2 450 kcal/d in males and 2000 kcal/d in females (Ter Borg et al. 2015). The mean intake of energy was 2137 kcal/d among males (n=14 419) and 1737 kcal/d among females (n=19 413) (Ter Borg et al. 2015).

Protein
Recommendations for sufficient protein intake have traditionally advised similar intakes for all adults, regardless of sex or age; 0.8 g/kg BW/d (Bauer et al. 2013). However, this recommendation does not consider age-related
changes in metabolism, immunity, hormone levels, or progression of frailty (Bauer et al. 2013). Several expert groups have suggested that the recommendation for protein intake should be increased to ≥1.0–1.2 g/kg BW/d to help maintain and regain muscle mass, muscle strength and physical function (Reinders et al. 2022). The PROT-AGE Study Group recommends the protein intake of older people to be 1.0–1.2 g/kg BW/d (Bauer et al. 2013). In the systematic review of Pedersen & Cederholm (2014), the authors conclude, that long-term prospective studies indicate that an intake of up to 1.2–1.5 g protein/kg BW/day (i.e. approximately 15–20 E%) is safe and may have beneficial effects among healthy older people. The Nordic Nutrition Recommendation and the Finnish recommendation suggests 1.2 - 1.4 g/kg BW/d for people aged ≥ 65 years (National Nutrition Council and Finnish Institute for Health and Welfare 2020, Nordic Council of Ministers 2012).

In the Prevention of Malnutrition in Senior Subjects in the EU (PROMISS) project, the study sample of 8107 older persons showed that protein intake among the community-dwelling elderly is often below the recommended intake (Hengeveld et al. 2020). The overall pooled prevalence of protein intake below recommendation was 22%, 47% and 71% using the 0.8, 1.0, and 1.2 cut-off value, respectively (Hengeveld et al. 2020). Lower intakes were observed among women, people with higher body mass index (BMI), and people with poor appetite (Hengeveld et al. 2020). In a Finnish study of family caregivers, 80% of older caregivers had inadequate intake of protein (Koponen et al. 2021).

In ten original studies, the total protein intake of older community-dwelling people has varied between 55 g/d and 90.3 g/d (Table 4) (Koponen et al. 2021, Kehoe et al.2021, Hengeveld et al. 2018, Valsta et al. 2018, Fernandez-Barres et al. 2016, Xu et al. 2015, Jyväskorpi et al. 2015, Power et al. 2014, Geirsdottir et al. 2013, Tieland et al. 2012). The protein intake calculated per bodyweight has been 0.95 g/kg BW/d to 1.2 g/kg BW/d, being lowest among older females in Iceland (Geirsdottir et al. 2013) and highest in older males in Finland (Jyväskorpi et al. 2015). In the National FinDiet Survey, the mean protein intake of Finnish males (n=204) and females (n=247) aged 65–74 years was 76 g/d and 66 g/d respectively (Valsta et al. 2018). In a systematic review of Ter Borg et al. (2015), the mean intake of total protein was 81 g/d and 1.0 g/kg BW/day among older male (n= 11 974) and 69 g/d and 1.1 g/kg BW/d among older female (n= 16 436). Generally, the gender differences in protein intake have not been as clear-cut as in energy intake. Males tend to have higher total protein intakes than females, but when looking at the intake calculated per bodyweight, the differences decrease or reverse, as in the review of Ter Borg et al. (2015).

In addition to gender differences in protein intake, differences exist on people’s knowledge of protein-rich foods and the importance of protein for
health. Visser et al. (2021) studied the protein knowledge (e.g. knowledge of good sources and the importance) of community-dwelling older people (≥65 years, n=1825) living in Finland, the Netherlands, Poland, Spain, and the United Kingdom. Poor protein knowledge was present in about half of these subjects (Visser et al. 2021). Being male, having a lower income, being unable to walk for 5 min and not always making food decisions were associated with poorer protein knowledge (Visser et al. 2021).

**Other nutrients**

Studies of older people in Europe have highlighted unfavourable intakes in fat, such as total fat, saturated fat, and monounsaturated fatty acid among older community-dwelling people (Kehoe et al. 2019, Valsta et al. 2018, Jyväskylä et al. 2015, Ter Borg et al. 2015). Excessive intakes of salt and sugar with low intakes of dietary fibre have decreased diet quality (Koponen et al. 2021, Kehoe et al. 2019, Valsta et al. 2018, Jyväskylä et al. 2015). Inadequate intakes of key micronutrients such as vitamins A, E, D, B2, B12, folate, thiamine, magnesium, iron, selenium and calcium, have also been reported (Koponen et al. 2021, Kehoe et al. 2019, Valsta et al. 2018, Fernandez-Barres et al. 2016, Jyväskylä et al. 2015).

In the Survey in Europe on Nutrition and the Elderly, a Concerted Action (SENECA), energy and micronutrient data from eight countries on 486 male and 519 female community-dwellers aged 74-79 years were collected (de Groot et al. 1999). They found that 47% of females, and 24% of males received inadequate amounts of at least one of the micronutrients (iron, thiamine, pyridoxine or riboflavin) (de Groot et al. 1999). The prevalence of inadequate micronutrient intakes decreased gradually with higher energy intakes; with energy intakes exceeding 1500 kcal, 19% of male and 26% of female still had an inadequate intake of at least one micronutrient (de Groot et al. 1999).
Table 4. Energy and nutrient intakes among older people living at home

<table>
<thead>
<tr>
<th>Study</th>
<th>Method</th>
<th>Population characteristics</th>
<th>Energy intake, mean (SD)</th>
<th>Protein intake, g/d, mean</th>
<th>Protein intake, g/BW kg/d, mean</th>
<th>Other nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Original studies</strong></td>
<td></td>
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</tr>
<tr>
<td>Koponen et al. 2021</td>
<td>3-day food record</td>
<td>125 older Finnish family caregivers, aged 74.6 years (SD 7.3), 90% female</td>
<td>1712</td>
<td>69.6</td>
<td>0.96</td>
<td>Over half had inadequate intake of vitamin A, folate, and fibre, and 25–40% of the family caregivers had a low intake of vitamin D, vitamin E, thiamine, magnesium, iron, and selenium</td>
</tr>
<tr>
<td>Kehoe et al. 2021</td>
<td>4-day weighed food record</td>
<td>226 older adults (≥65 years) in Ireland</td>
<td>1755</td>
<td>77.6</td>
<td>1.0</td>
<td>High intakes of total fat, SFA, sugars and salt and low intakes of dietary fibre compared to recommendations</td>
</tr>
<tr>
<td>Hengeveld et al. 2018</td>
<td>Block food-frequency questionnaire</td>
<td>2234 American community-dwelling older adults aged 70–79 years</td>
<td>1829</td>
<td>65.2</td>
<td>-</td>
<td>Low intakes of vitamin D, folate and fibre. High intakes of SFA and salt. In male, low intakes of vitamin A, and in females, low intakes of magnesium</td>
</tr>
<tr>
<td>Valsta et al. 2018</td>
<td>Two non-consecutive 24-hour dietary recalls</td>
<td>Older males (n=204) and females (n=247) in Finland, aged 65–74 years</td>
<td>1906 M</td>
<td>59.4</td>
<td>1.0</td>
<td>Calcium, vitamin D, vitamin E and folates intakes were less than two-thirds of the RDA and their probability of inadequate intake was &gt;85%</td>
</tr>
<tr>
<td>Fernandez-Barres et al. 2016</td>
<td>Semiquantitative validated Food Frequency Questionnaire</td>
<td>190 older (≥65 years) home care clients in Spain</td>
<td>1782</td>
<td>59.4</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Xu et al. 2015</td>
<td>24 h recalls over three days</td>
<td>2746 older Chinese people, aged ≥ 60 years</td>
<td>2236 M</td>
<td>66 M</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Jyväkorpi et al. 2015</td>
<td>1–3 day food records</td>
<td>Older Finnish people living at home (n=54), caregivers (n=97) with their care recipients (n=99, AD patients), aged ≥ 60 years</td>
<td>1313–1852</td>
<td>57.8–97.3</td>
<td>1.0–1.2</td>
<td>Low fiber and folate intakes and high SFA intake in all groups</td>
</tr>
<tr>
<td>Study</td>
<td>Method</td>
<td>Population characteristics</td>
<td>Energy intake, mean (SD)</td>
<td>Protein intake, g/d, mean</td>
<td>Protein intake, g/BW kg/d, mean</td>
<td>Other nutrients</td>
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<tr>
<td>Power et al. 2014</td>
<td>Semi-quantitative food frequency questionnaire (FFQ)</td>
<td>208 Irish (114 females) people, aged 64-93 years</td>
<td>2008 M 1668 F</td>
<td>79 M 68 F</td>
<td>-</td>
<td>A considerable proportion of subjects, particularly males, had inadequate intakes of calcium, magnesium, vitamin D, folate, zinc and vitamin C</td>
</tr>
<tr>
<td>Geirsdottir et al. 2013</td>
<td>3-day weighed food records</td>
<td>237 older people aged 65-92 years in Iceland</td>
<td>1881 M 1534 F</td>
<td>90.3 M 69.6 F</td>
<td>0.98 M 0.95 F</td>
<td>-</td>
</tr>
<tr>
<td>Tieland et al. 2012</td>
<td>2-day food records</td>
<td>707 older community-dwelling Dutch aged ≥ 65 years</td>
<td>2245 M (65-74 y) 2197 M (75-97 y) 1791 F (65-74 y) 1791 F (75-97 y)</td>
<td>85.9 M (65-74 y) 81.9 M (75-97 y) 72.9 F (65-74 y) 71.6 F (75-97 y)</td>
<td>1.11 M (65-74 y) 1.07 M (75-97 y) 1.03 F (65-74 y) 1.05 F (75-97 y)</td>
<td>-</td>
</tr>
<tr>
<td>Systematic review</td>
<td>Systematic review</td>
<td>International sample of 14 419 males and 19 413 females, aged ≥ 60 years</td>
<td>2137 M 1 737 F</td>
<td>81 M* 69 F*</td>
<td>1.0 M* 1.1 F*</td>
<td>SFA intake above recommendations and MUFA intake below</td>
</tr>
</tbody>
</table>

FFQ=food frequency questionnaire, BW=Body weight, M=Males, y=years, F=Females, SFA=Saturated fat, MUFA=Monounsaturated fatty acid, AD=Alzheimer’s disease. *=sample in protein intake analysis; 11 974 males and 16 436 females. None of the original studies included are included in the systematic review of Ter Bord et al. 2015.
2.2 Dietary guidance

ESPEN guidelines define nutritional care as an overarching term describing the form of nutrition, nutrient delivery and the system of education required to treat any nutrition-related condition in preventive and clinical nutrition (Cederholm et al. 2017). Dietary guidance is an ongoing process in which a healthcare professional, usually a trained nutritionist/registered dietitian, works with an individual to improve health and nutrition (Vasiloglou et al. 2019). Nutrition guidance is a two-way interaction with the individual, where nutritional background, possible problems, needs and goals are discussed together to enable identification of proper future steps and ways to meet the goals (Vasiloglou et al. 2019). Information, educational materials, support, and follow-up are provided to help the individual make and maintain the needed dietary changes. Physical, mental, psychological, social, clinical, and ethical aspects should be considered in the guidance (Volkert et al. 2019).

Dietary guidance is considered to be effective in management of numerous diseases, improving well-being, quality of life, health, and nutrient intake among older people (Vasiloglou et al. 2019, Agarwal et al. 2013, Baldwin & Weekes 2012). Improving eating habits has provided some of the strongest evidence for beneficial effects of nutrition on age-related outcomes (Wickramasinghe et al. 2020). ESPEN guidelines recommend, that older people with impaired nutritional status and their caregivers receive individualized dietary guidance to improve nutrition and support adequate dietary intake (Volkert et al. 2019). However, nutrition education has been a component in relatively few caregiver interventions (Suominen et al. 2015, Silver & Wellman 2002).

There are several ways to carry out nutritional education and guidance, e.g. training in cooking skills, provision of information on dietary requirements and the needs of older people and instructions on how to increase energy and nutrient intake (Rea et al. 2019). The guidance can be verbal or written, face-to-face or distant, one-to-one sessions or group sessions.

**Effectiveness of dietary guidance**

Dietary guidance studies with interventional or longitudinal descriptive designs were searched from the last 15 years (2006–2021). A total of eight original studies were found (Table 5), comprising four RCTs (Fernández-Barrés et al. 2017, Schilp et al. 2013, Rydwik et al. 2008, Rousset et al. 2006), two non-randomized controlled trials (Pöloinen et al. 2017, Nykänen et al. 2014), one retrospective qualitative observational study (Moreau et al. 2015) and one pre-posttest (Jyväkorpi et al. 2014). The nutritional interventions and durations varied. Tailored dietary guidance was given in the majority of the
studies (Fernández-Barrés et al. 2017, Pölönen et al. 2017, Nykänen et al. 2014, Jyväkorpí et al. 2014, Schipl et al. 2013, Rydwick et al. 2008, Rousset et al. 2006), and many interventions completed the guidance with additional group guidance sessions (Fernández-Barrés et al. 2017, Rydwick et al. 2008, Rousset et al. 2006) or cooking classes (Jyväkorpí et al. 2014). One study offered nutrition education-based cooking workshops (Moreau et al. 2015). Two studies included physical activity in addition to dietary guidance (Nykänen et al. 2014, Rydwick et al. 2008). In most of the studies, dietary guidance was performed by a trained nutritionist. The follow-up varied from two weeks (Rousset et al. 2006) to two years (Nykänen et al. 2014) and in the retrospective study the study period was four years (Moreau et al. 2015).

Interventions with tailored dietary guidance improved the nutritional status (MNA score) among community-dwelling older people (Nykänen et al. 2014), home care clients (Pölönen et al. 2017), and dependent patients whose caregivers were trained (Fernández-Barrés et al. 2017). Nutrient intakes were improved with tailored dietary guidance with group meetings (Fernández-Barrés et al. 2017, Rousset et al. 2006) or cooking classes (Jyväkorpí et al. 2014). In the study of Fernández-Barrés et al. (2017), there was an increase in protein intake (60.2 g/d vs. 64.3 g/d) in the intervention group over the 12 months of the intervention. Dietary habits (Fernández-Barrés et al. 2017, Moreau et al. 2015), diet quality (Jyväkorpí et al. 2014), nutrition-related knowledge and confidence (Moreau et al. 2015) and plasma albumin levels (Pölönen et al. 2017, Nykänen et al. 2014) also improved with the different dietary guidance interventions. An intervention with tailored dietary guidance complemented with cooking classes also showed an improvement in older people’s well-being (Jyväkorpí et al. 2014). In two studies, dietary guidance did no reveal any improvement in physical performance or nutrient intake (Schilp et al. 2013, Rydwick et al. 2008).

In four systematic reviews (Rea et al. 2019, Marshall et al. 2013, Bandayrel & Wong 2011, Young et al. 2011), the results were similar with nutritional education positively influencing nutrition-related outcomes (Rea et al. 2019, Young et al. 2011), improving physical function and reducing depression (Young et al. 2011). Involving caregivers in the intervention reduced nutritional risk and improved nutritional status (Rea et al. 2019, Marshall et al. 2013). Therefore, the involvement of caregivers as a component of nutritional care for community-dwelling older people is important (Marshall et al. 2013). Nutrition guidance interventions with active participation and collaboration have shown the most promising to affect nutrition-related outcomes, but future studies should also examine what kinds of interventions would benefit people with less active participation and health perceptions (Bandayrel & Wong 2011).
As Rea et al. (2019) and Young et al. (2011) concluded, the overall quality of the studies was hampered by poor methodology. Low sample size, risk of bias and insufficient data makes it challenging to draw any conclusions about the effectiveness of the interventions (Rea et al. 2019, Young et al. 2011). There is a need for high-quality randomized controlled trials to examine the effectiveness of community-based nutritional education for older adults living in the community (Rea et al. 2019). Interventions should be reported fully and the use of validated outcome measures, including a confirmed diagnosis of malnutrition, functional status and quality of life, is encouraged (Marshall et al. 2013). Sufficient follow-up is needed to determine longer term outcomes (Rea et al. 2019).
<table>
<thead>
<tr>
<th>Study</th>
<th>Study setting</th>
<th>Country</th>
<th>n</th>
<th>Age</th>
<th>Participants</th>
<th>Intervention/ data collection</th>
<th>Control group</th>
<th>Results</th>
<th>Conclusion and other findings</th>
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</thead>
<tbody>
<tr>
<td>Original interventional studies</td>
<td></td>
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<tr>
<td>Fernández-Barrés et al. 2017</td>
<td>Randomized controlled multicentre trial</td>
<td>Spain</td>
<td>190</td>
<td>≥65 y</td>
<td>Community-dwelling dependent patients at risk of malnutrition and who had caregivers</td>
<td>Over six-months, nurses conducted nutritional intervention sessions for caregivers and then monitored them at home every month. Intervention included individualized dietary advice (consequences of malnutrition etc.) and group meetings.</td>
<td>Regular home care visit</td>
<td>Improvement in MNA score, dietary habits and nutritional intake (protein, polyunsaturated fatty acids, folate, vitamin E) of older, community-dwelling dependent patients. Protein intake increased from 60.2 g/d to 64.3 g/d in the intervention group over the 12 months of the intervention</td>
<td>More research is needed to include a nutrition education intervention as a part of home care</td>
</tr>
<tr>
<td>Pölönen et al. 2017</td>
<td>Non-randomized controlled study.</td>
<td>Finland</td>
<td>224</td>
<td>≥75 y</td>
<td>Home care clients with PEM or risk of PEM</td>
<td>During the six-month follow-up, two dietary guidance meetings with the nutritionist to correct possible inadequacies in the diet and to recommend foods.</td>
<td>Regular treatment</td>
<td>After the six-month nutritional intervention, the MNA score and plasma albumin increased, whereas in the control group they decreased</td>
<td>Individually tailored dietary guidance can improve nutritional status among older home care clients</td>
</tr>
<tr>
<td>Moreau et al. 2015</td>
<td>Retrospective qualitative observational study</td>
<td>Canada</td>
<td>144</td>
<td>≥50 y</td>
<td>Community-dwelling people</td>
<td>Effect of nutrition education-based cooking workshops for eight times. Registered dietitian used standardized teaching materials and menus consistent with</td>
<td>-</td>
<td>Over the four years that the workshops were held, 23 groups of 4–10 participants completed pre- and post-session questionnaires. Improvements in nutrition-related knowledge, confidence, and dietary habits. Association found</td>
<td>Interventions that link nutrition knowledge to cooking competence offer a good way to improve dietary habits</td>
</tr>
<tr>
<td>Study</td>
<td>Study setting</td>
<td>Country</td>
<td>n</td>
<td>Age</td>
<td>Participants</td>
<td>Intervention/ data collection</td>
<td>Control group</td>
<td>Results</td>
<td>Conclusion and other findings</td>
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<tr>
<td>Nykänen et al. 2014</td>
<td>Non-randomized controlled study.</td>
<td>Finland</td>
<td>173</td>
<td>≥75 y</td>
<td>Community-dwelling people</td>
<td>Nutritional intervention (two meetings with nutritionist) with components of medical and physical intervention.</td>
<td>-</td>
<td>At the two-year follow-up, the mean MNA scores and serum albumin increased in the intervention group and decreased in the control group.</td>
<td>Dietary guidance without nutritional supplements can improve nutritional status.</td>
</tr>
<tr>
<td>Jyväkorp i et al. 2014</td>
<td>Pre-post-test intervention</td>
<td>Finland</td>
<td>54</td>
<td>≥60 y</td>
<td>Community-dwelling people</td>
<td>Effect of nutritional education combined with cooking classes on older people’s nutrition and psychological well-being</td>
<td>-</td>
<td>At the four-month follow-up, participants had improved diet quality and well-being and higher intakes of vitamin C and fiber.</td>
<td>Interventions tailored to everyday life, including food preparation and social aspects, may be effective in improving nutrition and psychological wellbeing among older people.</td>
</tr>
<tr>
<td>Schilp et al. 2013</td>
<td>Parallel randomized controlled trial</td>
<td>Netherlands</td>
<td>146</td>
<td>≥65 y</td>
<td>Non-institutionalized, undernourished individuals in primary care</td>
<td>Dietary guidance from a qualified trained dietitian. Combination of both face-to-face and telephone consultations as often as needed.</td>
<td>Usual care, not referred to a dietitian during the study</td>
<td>At six months, dietetic treatment had no effect on body weight, physical performance, handgrip strength, fat-free mass, energy intake, or protein intake.</td>
<td>Long-term, multidisciplinary approach for successful treatment of undernutrition in primary care should be studied.</td>
</tr>
<tr>
<td>Rydwik et al. 2008</td>
<td>Randomized controlled trial</td>
<td>Sweden</td>
<td>96</td>
<td>≥75 y</td>
<td>Community-dwelling older people</td>
<td>12-week intervention in three different groups to improve physical</td>
<td>No treatment</td>
<td>Nutrition intervention did not show any significant results in physical performance</td>
<td>Intervention with physical activity showed better improvement than</td>
</tr>
<tr>
<td>Study</td>
<td>Study setting</td>
<td>Country</td>
<td>n</td>
<td>Age</td>
<td>Participants</td>
<td>Intervention/ data collection</td>
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<td>Results</td>
<td>Conclusion and other findings</td>
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<tr>
<td>Rousset et al. 2006</td>
<td>Randomized controlled trial</td>
<td>France</td>
<td>82</td>
<td>65 - 75 y</td>
<td>Community-dwelling older people</td>
<td>Two-week information programme targeting protein consumption. One professional group lecture and personal feedback of the participant's dietary surveys.</td>
<td>No treatment</td>
<td>Intervention group increased their protein intake by 0.041 g/lb/da (1 lb= 0.45 kg), with a greater increase for females than for the males.</td>
<td>It is possible to change dietary practice and knowledge among elderly people by information targeting one nutrition message</td>
</tr>
</tbody>
</table>

**Systematic reviews**

<table>
<thead>
<tr>
<th>Study</th>
<th>Study setting</th>
<th>Country</th>
<th>n*</th>
<th>Age</th>
<th>Participants</th>
<th>Intervention/ data collection</th>
<th>Control group</th>
<th>Results</th>
<th>Conclusion and other findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rea et al. 2019</td>
<td>Systematic review</td>
<td>Internati</td>
<td>9*</td>
<td>Mean age ≥ 60 y</td>
<td>Studies with community-dwelling older people or their caregivers</td>
<td>Studies examining nutrition educational interventions to improve nutritional and other health-related outcomes</td>
<td>-</td>
<td>Nutrition education may improve nutrition-related outcomes. Involving caregivers was found to reduce nutritional risk. Dietary guidance following discharge from hospital reduced the risk of re-admission.</td>
<td>Quality of the studies was confounded by poor methodology, low sample size and attrition bias.</td>
</tr>
<tr>
<td>Marshall et al. 2013</td>
<td>Systematic review</td>
<td>Internati</td>
<td>9*</td>
<td>≥65 y</td>
<td>Studies with community-dwelling older people</td>
<td>Studies examining the impact of nutrition-related interventions delivered to or by</td>
<td>-</td>
<td>Majority of interventions were delivered to informal carers (6 studies). Five interventions prevented/treated</td>
<td>Involvement of non-clinical community care workers and informal carers as part of the</td>
</tr>
<tr>
<td>Study</td>
<td>Study setting</td>
<td>Country</td>
<td>n</td>
<td>Age</td>
<td>Participants</td>
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<tr>
<td>Bandayr el &amp; Wong 2011</td>
<td>Systematic review</td>
<td>International research</td>
<td>15*</td>
<td>Mean age ≥ 55 y</td>
<td>Studies with community-dwelling older people</td>
<td>RCTs involving nutrition-related outcomes in community-dwelling older adults</td>
<td>-</td>
<td>Nutrition guidance interventions with active participation and collaboration showed the most promising impact on nutrition-related outcomes</td>
<td>Future studies should examine what kind of interventions will benefit community-dwelling older people with less active participation and health perceptions, and lower educational level.</td>
</tr>
<tr>
<td>Young et al. 2011</td>
<td>Systematic review</td>
<td>International research</td>
<td>23*</td>
<td>≥ 65 y</td>
<td>Studies with community-dwelling older people</td>
<td>Studies evaluating the effectiveness of nutritional education on physical function, emotional health, quality of life, nutritional indices, anthropometric indicators, mortality, service use and costs of care</td>
<td>-</td>
<td>Nutritional education can positively influence diet, improve physical function and reduce depression. Impact on weight change was inconclusive and no evidence was found of an improvement in anxiety, quality of life, service use, costs of care or mortality</td>
<td>Many studies had risk of bias, and for some outcomes the data were insufficient to draw conclusions about effectiveness</td>
</tr>
</tbody>
</table>

* Number of studies. y= years, PEM= protein-energy malnutrition, MNA= Mini Nutritional Assessment. Studies from the last 15 years (2006–2021) were included. Most of the studies are conducted among participants aged ≥65 y, but there are few studies that included also younger participants.
2.3 Home-delivered meals

Home-delivered meals, home-meals, meals-on-wheels and home-meal service are often used terms to describe a meal service, where the client receives fresh or frozen prepared meals and/or snacks at home. In this doctoral dissertation, the term home-delivered meals is used to describe the service.

Home-delivered meal services are an example of a nutritional intervention in the home setting developed to improve dietary intake and contribute to the health and independence of especially older people (Ijmker-Hemink et al. 2020, Campbell et al. 2015). There is a great worldwide variation in how services operate, what meals are delivered and how many times per week food is delivered. The often used term “meals-on-wheels” has its origins in Great Britain, where the Women’s Volunteer Service for Civil Defense delivered home-cooked meals to service personnel and civilians during World War II. Because the meals were often delivered in baby carriages, the term meals-on-wheels was coined and it now refers generically to home-delivered meals programmes throughout the world (Campbell et al. 2015).

Effect of home-delivered meals on nutrition

International research of home-delivered meal studies with intervention or longitudinal descriptive designs were searched from the last 15 years (2006–2021). A total of nine studies were found (Table 6). Two of the studies were RCTs (Borkent et al. 2019, Ziyalan et al. 2017), three pre-posttests (Ullevig et al. 2018, Wright et al. 2015, Charlton et al. 2013), three quasi-experimental studies (Denissen et al. 2017, Frongillo & Wolfe 2010, Roy & Payette 2006) and one randomized crossover counterbalanced study (Silver et al. 2008). The interventional element was either enriched products (Borkent et al. 2019, Ziyalan et al. 2017, Silver et al. 2008), home-delivered meals with snacks (Denissen et al. 2017, Charlton et al. 2013) or either new or existing regular home-delivered meal service (Ullevifg et al. 2018, Wright et al. 2015, Frongillo & Wolfe 2010, Roy & Payette 2006).

According to several of these studies, home-delivered meals has increased participants’ protein intake (Borkent et al. 2019, Ziyalan et al. 2017, Wright et al. 2015, Charlton et al. 2013, Silver et al. 2008, Roy & Payette 2006), with different kinds of methods from additional snacks (Charlton et al. 2013) to protein enriched products (Borkent et al. 2019, Ziyalan et al. 2017, Silver et al. 2008). An important finding was also discovered by Borkent et al. (2019), as they showed that switching from a regular diet to ready-made meals carries the risk of a decreasing protein intake if meals are not selected for high protein content. There has also been a significant increase in energy intake (Wright et al. 2015, Charlton et al. 2013, Silver et al. 2008, Roy & Payette 2006) and other

Home-delivered meals have also improved participants’ nutritional status (Ullevig et al. 2018, Wright et al. 2015, Charlton et al. 2013) assessed with MNA and the Nutrition Screening Initiative. Physical changes such as increased weight and BMI have been shown in two studies (Denissen et al. 2017, Charlton et al. 2013), and an increase in upper leg circumference and fat free mass in one study (Denissen et al. 2017).

The results of the home-delivered meal service reviews are similar to the results above. Recent systematic reviews of international research have concluded, that older people receiving home-delivered meals are at high risk of undernutrition and providing home-delivered meals may improve nutritional status and nutrient intake, such as energy and protein intakes (Fleury et al. 2021, Walton et al. 2020, IJmker-Hemink et al.2020, Zhu & Ann 2013). In the review of Fleury et al. (2021), they point out that the improvement of recipients’ nutrition is even greater when the home meal service either provide nutrition guidance or add supplementary snacks/meals or calorie/protein-enriched foods (Fleury et al. 2021). The same result was shown in the systematic review of IJmker-Hemink et al. (2020), as they pointed out that provision of protein-enriched bread or snacks in addition to meals can improve the home-delivered meals service outcomes in energy and protein intake. Home-delivered meals seem to improve nutritional care at home (IJmker-Hemink et al. 2020) and help older people maintain their independence and remain in their homes and communities as their health and functioning decline (Zhu & Ann 2013). Campbell et al. (2015) conducted a comprehensive and systematic review of all studies related to home-delivered meals and found that most studies are descriptive, do not report on outcomes, have a small sample size, and are limited to a particular setting or participant population. More appropriate research, including randomized controlled trials and large observational studies, is needed to evaluate the effectiveness of home-delivered meals for older people in multiple outcomes (Campbell et al. 2015).
Table 6. Studies of the effects of home-delivered meals on older people’s nutrition

<table>
<thead>
<tr>
<th>Study</th>
<th>Study setting</th>
<th>Country</th>
<th>n</th>
<th>age</th>
<th>Participants</th>
<th>Intervention/ data collection</th>
<th>Control group</th>
<th>Results</th>
<th>Conclusion and other findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original interventional studies</td>
<td></td>
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</tr>
<tr>
<td>2019 Borkent et al.</td>
<td>Single-blind randomized trial</td>
<td>Netherlands</td>
<td>98</td>
<td>Mean age 80.4 y</td>
<td>Community-dwelling older adults</td>
<td>Home-delivered protein-rich ready-made meals and dairy products for 28 days. Aim to reach the recommended intake of 1.2 g protein/kgBW/d and ≥25 g of protein per meal.</td>
<td>Received products lower in protein</td>
<td>Protein intake in intervention group was significantly higher than in control group (1.12 g/kgBW/d vs. 0.87 g/kgBW/d), but the intervention was not effective in increasing protein intake to 1.2 g protein/kg BW/d. More participants of the intervention group reached ≥25 g protein at dinner than in the control group but not at breakfast or lunch.</td>
<td>Switching from a regular diet to ready-made meals carries the risk of decreasing protein intake if meals are not selected for high protein content.</td>
</tr>
<tr>
<td>2018 Ullevig et al.</td>
<td>Pre-posttest</td>
<td>USA</td>
<td>49</td>
<td>≥60 y</td>
<td>People receiving HDM, without dementia or terminal illness</td>
<td>No intervention. Data collected before and after 3 months of HDM services.</td>
<td>Participants' personal data before HDM.</td>
<td>After receiving 3 months of HDM, nutrition status significantly improved as measured by the NSI and MNA. More participants met or exceeded the recommended dietary intake for magnesium and zinc after receiving HDM than before receiving HDM.</td>
<td>Improvements in nutrition status were found after 3 months of receiving HDM, whereas intake of most nutrients did not change significantly.</td>
</tr>
<tr>
<td>2017 Denissen et al.</td>
<td>Quasi-experimental</td>
<td>Netherlands</td>
<td>44</td>
<td>&gt;70 y</td>
<td>Functionally disabled community-dwelling older people receiving home care</td>
<td>Three-month daily meal service consisting of dinner and snacks.</td>
<td>Older people without meal service</td>
<td>Significantly greater increase in intervention group in body weight, BMI, upper leg circumference and FFM than in control group. Intervention group had higher intake of calcium. 3 months post-intervention, the increase in FFM remained significant.</td>
<td>Home meal service was highly appreciated and had a rapid effect on fat free mass.</td>
</tr>
<tr>
<td>2017 Ziylan et al.</td>
<td>Double-blind randomized controlled trial</td>
<td>Netherlands</td>
<td>42</td>
<td>Mean age 74.0 y</td>
<td>Community-dwelling older residents (≥65 y)</td>
<td>5 protein-enriched readymade meals and plentiful protein-enriched bread over 2 weeks.</td>
<td>Control group received the regular equivalents.</td>
<td>Total daily protein intake in intervention group was significantly higher than in the control group (87.7 vs 73.1 g/d) and per BW (1.25 vs 0.99 g/kg/d).</td>
<td>Protein intake can be increased to recommended levels with protein-enriched products.</td>
</tr>
<tr>
<td>Study</td>
<td>Study setting</td>
<td>Country</td>
<td>n</td>
<td>age</td>
<td>Participants</td>
<td>Intervention/ data collection</td>
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<td>Results</td>
<td>Conclusion and other findings</td>
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<tr>
<td>2015 Wright et al.</td>
<td>Pre-posttest</td>
<td>USA</td>
<td>51</td>
<td>≥60 y, mean age 74 y</td>
<td>Clients enrolled in the HDM programme</td>
<td>Assessment of nutritional status (MNA), dietary intake, well-being, loneliness, and food security levels.</td>
<td>-</td>
<td>Receiving home-delivered meals for a short duration significantly improved nutritional status, dietary intake, food security, loneliness, and mental well-being.</td>
<td>HDM programs are a cost-effective method of improving nutritional health and social well-being.</td>
</tr>
<tr>
<td>2013 Charlton et al.</td>
<td>Pre-posttest</td>
<td>Australia</td>
<td>13</td>
<td>Mean age 81 y</td>
<td>HDM recipients at risk of undernutrition or under-nourished</td>
<td>Participants received snacks five times a week, in addition to their usual HDM for 4 weeks. Pre-post changes in dietary intake assessed.</td>
<td>-</td>
<td>Post-intervention, there was a trend for an increased energy (+415kJ=99 kcal/d) and protein (+7.2 g/d) intake. MNA scores, BMI and body weight significantly increased.</td>
<td>Additional daily mid-meal snack may be a useful addition to existing HDM services, for improved energy and protein intakes.</td>
</tr>
<tr>
<td>2010 Frongillo &amp; Wolfe.</td>
<td>Quasi-experimental</td>
<td>USA</td>
<td>212</td>
<td>≥60 y</td>
<td>Older persons referred for ageing services</td>
<td>Assessment of individuals on HDM at baseline, 6 and 12 months (weight, height, 24-hour dietary recall, food insecurity).</td>
<td>Comparison with non-randomized group receiving other services.</td>
<td>HDM participants had significantly improved dietary patterns, nutrient intake, and nutrient density, and lessened food insecurity, compared with initial values and with groups not receiving meals.</td>
<td>HDM improved nutritional well-being and had a greater impact on participants living alone than on those living with others.</td>
</tr>
<tr>
<td>2008 Silver et al.</td>
<td>Randomized crossover counter-balanced design, within subject</td>
<td>USA</td>
<td>45</td>
<td>Mean age 84.4 y</td>
<td>Free living HDM recipients</td>
<td>Regular and enhanced version of a lunch meal on alternate weeks for 1 week. In enriched lunches energy density twice the regular version and 10 g more protein.</td>
<td>Delivery of regular lunches.</td>
<td>Consumption of the enhanced meal increased significantly the average lunch energy intakes by 86% and 24-hour energy intakes by 453 kcal. The 24-hour intakes of several key macronutrients and micronutrients also improved.</td>
<td>Energy and protein intakes: higher with enriched lunches than with regular lunches.</td>
</tr>
<tr>
<td>2006 Roy &amp; Payette</td>
<td>Quasi-experimental</td>
<td>Canada</td>
<td>51</td>
<td>Mean age 76.4 y</td>
<td>Newly enrolled HDM recipients</td>
<td>No intervention. Evaluated the effect of Meals-on-Wheels (MOW) on dietary intakes in the experimental group.</td>
<td>An untreated control group.</td>
<td>At post-test, intake of most nutrients increased in the experimental group compared with the control group. Increases were significant for energy, protein, lipid and thiamin.</td>
<td>MOW programmes (HDM) improve dietary intakes of recipients.</td>
</tr>
<tr>
<td>Study</td>
<td>Study setting</td>
<td>Country</td>
<td>n</td>
<td>age</td>
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<tr>
<td>2021 Fleury et al.</td>
<td>Systematic review</td>
<td>International</td>
<td>48*</td>
<td>&gt;60 y</td>
<td>Older adults living at home and receiving home-delivered meal services were eligible</td>
<td>Systematic review of all studies related to the nutritional issue in HDM older recipients.</td>
<td>-</td>
<td>HDM recipients are at high risk of undernutrition. HDM may improve the nutritional status and nutrient intake. Improvement is higher when HDM service is enhanced with dietetic counseling/supplementary snacks or meals/enriched food.</td>
<td>There is a need to further develop strategies allowing HDM recipients to fulfill their nutritional needs.</td>
</tr>
<tr>
<td>Walton et al. 2020</td>
<td>Systematic review</td>
<td>USA, Canada, Australia</td>
<td>13*</td>
<td>&gt;50 y</td>
<td>Older adults living at home</td>
<td>Evaluation of nutritional intake in community-living older adults when receiving HDM</td>
<td>-</td>
<td>Beneficial effect of home-delivered meals on dietary intake of energy, protein and/or certain micronutrients in older adults.</td>
<td>Increased intakes of energy and protein and a particular increase in calcium intake.</td>
</tr>
<tr>
<td>2020 IJmker-Hemink et al.</td>
<td>Systematic review</td>
<td>International</td>
<td>19*</td>
<td>&gt;60 y</td>
<td>Healthy adults</td>
<td>Elements of HDM services to improve energy and protein intake, nutritional status, functionality and satisfaction</td>
<td>-</td>
<td>HDM providing protein-enriched bread or snacks in addition to meals or providing meals and snacks for whole days can improve outcomes (energy and protein intake and satisfaction).</td>
<td>There is a great need to optimize HDM services to improve nutritional care at home.</td>
</tr>
<tr>
<td>2015 Campbell</td>
<td>Systematic review</td>
<td>USA</td>
<td>80*</td>
<td>≥45 y</td>
<td>HDM recipients</td>
<td>Systematic review of all studies related to HDM in order to shed light on the state of the science.</td>
<td>-</td>
<td>From 80 studies, most studies were descriptive and did not report outcomes. The most commonly reported outcomes was nutritional status.</td>
<td>RCTs and large observational studies, are needed to evaluate the efficacy and effectiveness.</td>
</tr>
<tr>
<td>2013 Zhu &amp; Ann</td>
<td>Review</td>
<td>International</td>
<td>8*</td>
<td>≥60 y</td>
<td>Homebound older people</td>
<td>Review of the scientific evidence on the impact of home-delivered meal services on diet and nutrition among recipients.</td>
<td>-</td>
<td>From eight studies, all but two studies found HDM to improve diet quality, increase nutrient intakes, and reduce food insecurity and nutritional risk. It increased socialization opportunities and improved dietary adherence and QoL.</td>
<td>HDM programmes improve diet quality and increase nutrient intakes. They help older people maintain independence and remain in their homes and communities.</td>
</tr>
</tbody>
</table>

* Number of studies. BMI= Body Mass Index, FFM=Fat free mass, NSI=Nutrition Screening Initiative, BW=Body weight, MNA= Mini Nutritional Assessment, HDM= Home-delivered meals. Original interventional studies: participants aged ≥60 years and living at home were included from the last 15 years (2006–2021). In the review studies, study populations varied, and even though they focused on the older population, some studies had participants aged ≥45 years (minority of all participants).
**Effect on physical performance**

Research data of interventional trials studying the effects of home-delivered meals on physical performance remain scarce. Leedo et al. (2017) found that home-delivered meals with snacks improved lower body strength and performance status measured with Chair Stand Test and the Eastern Cooperative Oncology Group Performance Status among lung cancer patients. The results are important, since the Chair Stand Test is one of the most important functional evaluation tests because it relates to daily life activities, such as climbing stairs, getting up from a chair, or rising from a horizontal position (Leedo et al. 2017).

A randomized controlled trial (Beelen et al. 2017) studying the effectiveness of a 12-week intervention with protein-enriched foods and drinks after hospital discharge found no improvement between the intervention and control group in Short Physical Performance Battery total score, gait speed and chair-rise time (Beelen et al. 2017). The results may be explained by the fact that for people with adequate protein intake and limited physical activity, protein enrichment did not enhance physical recovery (Beelen et al. 2017). However, the results improved within the intervention group from baseline to final measurements indicating some positive changes. No changes were seen in leg-extension strength, hand-grip strength, and independence in activities of daily living (Beelen et al. 2017).

No improvement in hand-grip strength was also reported in a study with a three-month daily home-delivered meal service consisting of dinner and snacks among functionally disabled community-dwelling older people receiving home care (Denissen et al. 2017). However, the authors found a significant positive effect of home-delivered meal intervention on fat-free mass and upper leg circumference, indicating, that the intervention may have affected lower extremity strength, rather than upper extremity strength (Denissen et al. 2017). Also, a three-week home-delivered meals service (three meals a day) intervention among community-dwelling older people found no improvement in hand-grip strength (O’Leary et al. 2020).

The drawbacks of home-delivered meal studies with physical outcomes are probably the short durations of the interventions (O’Leary et al. 2020, Beelen et al. 2017) and the ceiling effect of the nutrient intakes among some of the participants, meaning that they may have already attained the recommended nutrient intake and therefore do not benefit from the intervention. Combining home-delivered meals with a resistance-type exercise programme could bring more positive effects on physical-performance outcomes (Beelen et al. 2017). Future research on the effectiveness of home-delivered meals should focus on longer-lasting interventions, larger sample sizes and detailed outcome assessment with food diaries and evaluation of physical performance (Denissen et al. 2017).
Effect on quality of life

Interventions designed to improve nutritional status can also lead to significant improvements in both physical and mental aspects of quality of life (Rasheed & Woods 2013). Few studies report on the effectiveness of home-delivered meals on older community-dwelling people’s quality of life. Leedo et al. (2017) examined the effects of energy- and protein-rich home-delivered meals and snacks on quality of life in malnourished Danish outpatients suffering from lung cancer, but found no improvement. Also, Denissen et al. (2017) evaluated functionally disabled community-dwelling older participants receiving a three-month daily meal service consisting of dinner and snacks, but noted no effect on quality of life quality.

One study reported positive a effect of home-delivered meals on quality of life. Gleason et al. (2002) investigated whether home-delivered, heart-healthy meals and snacks, combined with telephone dietary guidance, would be efficacious in improving dietary compliance, quality of life, and cardiovascular risk factors in coronary heart disease patients. Significant improvements in quality of life were observed. Those receiving home-delivered meals may have had fewer worries and concerns about making good food choices, because of the dietary guidance, which may have reduced anxiety and improved mood and health perceptions (Gleason et al. 2002). Since information on the effects of home-delivered meals on quality of life remains slight, further good-quality research and larger RCTs are needed.
3 SUMMARY OF PREVIOUS RESEARCH

Older community-dwelling individuals may have variety of risk factors, that increase the risk of nutritional problems. Changes in the family situations, physical or psychosocial problems, and other health issues are examples of the common situations that the increasing age may bring. When the need for care increases, also the prevalence of malnutrition and other nutritional problems increases. Approximately every fourth of the community-dwelling older people have increased risk of malnutrition. The prevalence is higher among older caregivers and much higher among home care clients and care recipients, where the majority of all have increased risk of malnutrition. Because of the increased vulnerability of this life stage, a greater focus on nutritional status and dietary intake should be given.

Even though several studies have studied the prevalence of malnutrition in community-dwelling older people, less studies have explored the nutrient intakes in this population. Low energy and protein intake has been a concern based on previous international studies, but more information on the intakes among community-dwelling older people in Finland is needed. Also, less studies have included older caregivers, even though they may have increased risk of malnutrition, and are recognized as an important target group for dietary guidance.

Effective, individualized and evidence-based nutritional support should be identified and offered to prevent and treat malnutrition among older people. Dietary guidance with variety of methods have shown to be effective in improving nutritional status and nutrient intake among older people. The effectiveness of home-delivered meals on the nutritional status, nutrient intake and food insecurity has been showed, but their effectiveness on physical performance or quality of life is unclear. The challenge to show the effectiveness of these nutritional interventions are, that the quality of most studies is poor due to poor methodology. Studies with dietary guidance have had low overall quality. In addition, many of the studies exploring effectiveness of home-delivered meals have been descriptive and do not report on outcomes. There is a need for high-quality randomised controlled trials to study the effectiveness of community-based dietary guidance and to evaluate the effectiveness of home-delivered meals for older people living in the community.
4 AIMS OF THE STUDY

The overall aim of this doctoral dissertation was to investigate nutritional status and nutrient intakes among community-dwelling caregivers and people receiving care (care recipients and home care clients) aged ≥65 years and to study the effectiveness of tailored dietary guidance and home-meal service.

Specific aims were as follows:

1. To evaluate nutritional status, nutrient intake, and factors associated with these among older community-dwelling caregivers and people receiving care (Studies I and III).

2. To assess the effectiveness of tailored dietary guidance in protein intake among older caregivers, especially males (Study II).

3. To evaluate the effectiveness of an 8-week home-meal service in protein intake and other nutrients, physical performance, and quality of life among older community-dwelling caregivers and people receiving care (Study IV).
5 METHODS

5.1 Study designs and participants

The study comprises two randomized controlled trials: the CareNutrition trial, which aimed at investigating the effectiveness of tailored dietary guidance in protein intake and wellbeing among older caregivers, especially males (≥65 years) (Studies I and II), and the Power Meals trial, which examined the effectiveness of home-delivered meals in protein intake and other nutrients, physical performance, and quality of life among older people (≥65 years) (Studies III and IV). The trials are presented in more detail in the subsequent sections and in Table 7.

**CareNutrition trial (Studies I and II)**

The CareNutrition trial (2016-2017) was a randomized controlled trial study exploring the effectiveness of a six-month tailored dietary guidance in protein intake and wellbeing among older caregivers (≥65 years) and recipients of care (≥50 years). The results of the older caregiver participants are reported here. The trial was conducted at the Pori Social and Health Services (cities of Pori, Ulvila and Merikarvia). All caregivers had officially approved status of a caregiver by the Social Insurance Institution of Finland.

Participant recruitment is described in Figure 2. Inclusion criteria and participant characteristics are presented in Table 7. Caregivers were recruited for the study during caregivers’ well-being and health screenings, which were performed by healthcare nurses in two clusters in autumn 2015 and spring 2016. Caregivers were invited from the Disability services of Pori Social and Heath Services (caregivers aged ≥65 y) and from the Elderly services of Pori Social and Health Services (being caregiver for at least three years). During the health screen the nurses gave the study information brochure to the caregiver if they fulfilled the inclusion criteria. If the caregiver showed an interest in participating the study, a home visit was scheduled. The study nutritionist made a home visit during which oral and written information about the study was provided, and participants had the opportunity to discuss the study. An informed consent was obtained and part of the baseline measurements were performed. If the caregiver participated in the study, data from the nurse’s appointment were used as baseline measurements. After the home visit, an experienced geriatrician reviewed the participant documents (baseline measurements) and evaluated the participant’s ability to participate in the study. After the geriatric evaluation, participants were enrolled in the study and randomized to either the intervention group (guidance group) or the control group.
368 Caregivers (aged ≤ 65 in the Disability services of Pori Social and Health services, being caregiver for at least three years in the Elderly services of Pori Social and Health Services) invited to Health screening

169 (46 %) caregivers participated in the health screenings in Autumn 2015 and Spring 2016

159 caregivers were invited to participate the trial (10 excluded; age ≤ 65)

92 showed interest and volunteered for the CareNutrition trial

79 caregivers eligible for the study (13 excluded; 7 not meeting the inclusion criteria, 6 declined to participate after interview)

Randomization

Guidance group
40 caregivers

Control group
39 caregivers

34 caregivers included in the final assessment (5 informal care ended, 1 wanted to drop out)

35 caregivers included in the final assessment (4 informal care ended)

Figure 2. Flow chart of the Care Nutrition trial.
Power Meals trial (Studies III and IV)
The Power Meals trial (2018) was a randomized, controlled, three-arm parallel-group study exploring the effectiveness of home-delivered meals in protein intake and other nutrients, physical performance, and quality of life among older people (≥65 years) living at home. The eight-week intervention in two different groups included daily either a protein-rich home meal, snack, and bread in the intervention 1 group (protein group) or regular home meals in the intervention 2 group (regular group). The control group maintained their usual diet without a home meal service. The trial was conducted at the Pori Social and Health Services (cities of Pori and Ulvila).

Participant recruitment is described in Figure 3. Inclusion criteria and participant characteristics are presented in Table 7. Home care nurses and the informal care contact persons selected potential participants based on inclusion criteria. During the home care visit, the nurse gave the study information brochure, or the brochure was sent by mail to the client. The informal care contact persons contacted (by phone) the caregivers and care recipients and presented the study protocol. Participants who wanted to participate were asked to contact the study nutritionist via telephone or the nurses forwarded a call request to the study nutritionist. The nutritionist explained the study procedure thoroughly and scheduled a home visit. During the home visit the study procedures were described and discussed again, and inclusion criteria were ensured. An informed consent was obtained, and part of the baseline measurements were performed. After the home visit, the participant went to the main healthcare center of Pori Social and Health Services for the nurse’s and the geriatrician’s appointment. At the nurse’s appointment, baseline measurements (physical tests, MMSE) were performed. After the nurse’s appointment, every participant met the research team geriatrician, who interviewed the participant and reviewed the participant’s self-filled questionnaires and results from the baseline measurements. Based on the measurements and interview, the geriatrician evaluated the participant’s ability to participate, and participants were enrolled in the study.
170 telephone calls (made to people who showed interest in the study) to explain the study and to assess eligibility

Excluded after telephone call:
- 51 declined to participate,
- 15 failed to meet the inclusion criteria (cognition, restricted diet (based on interview)),
- 16 cancelled home visit (decreased health, changed mind, admission to hospital)

88 home visits made (inclusion criteria rechecked, informed consent, baseline measurements)

Excluded after home visit:
- 4 cancelled informed consent, 3 failed to meet the inclusion criteria (cognition, health status),
- 1 admission to hospital

80 attended appointments with the nurse and geriatrician (baseline measurements, geriatric evaluation)

Excluded after appointment with nurse and geriatrician:
- 2 cancelled participations

78 participants randomized

Protein group
28 participants
(9 home care clients, 1 spouse of home care client, 10 caregivers, 8 care recipients)

3 withdrawn (dissatisfied with the food), 2 died, 1 admission to hospital

22 finished the trial

Regular group
25 participants
(9 home care clients, 8 caregivers, 8 care recipients)

1 withdrawn (dissatisfied with the food)

24 finished the trial

Control group
25 participants
(12 home care clients, 1 spouse of home care client, 5 caregivers, 7 care recipients)

4 withdrawn (dissatisfied with randomization to control group)

21 finished the trial

80 attended appointments with the nurse and geriatrician (baseline measurements, geriatric evaluation)

Figure 3. The flow chart of the Power Meals trial study
Table 7. Characteristics of the studies

<table>
<thead>
<tr>
<th>Study design</th>
<th>Intervention</th>
<th>CareNutrition trial (Study I)</th>
<th>Power Meals trial (Study II)</th>
<th>CareNutrition trial (Study III)</th>
<th>Power Meals trial (Study IV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-sectional</td>
<td>Dietary guidance</td>
<td>79 (baseline)</td>
<td>55 (completers)</td>
<td>78 (baseline)</td>
<td>67 (completers)</td>
</tr>
<tr>
<td>Interventions</td>
<td></td>
<td>Caregivers in Pori Social and Health Services (official caregiver status)</td>
<td>Caregivers in Pori Social and Health Services (official caregiver status)</td>
<td>Client of Pori Social and Health Services: -home care client (and older spouse/companion living in the same household) - caregiver (official caregiver status) - care recipient (of the caregiver)</td>
<td>Client of Pori Social and Health Services: -home care client (and older spouse/companion living in the same household) - caregiver (official caregiver status) - care recipient (of the caregiver)</td>
</tr>
<tr>
<td>Females %</td>
<td>62</td>
<td>55</td>
<td>47</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Age range, years</td>
<td>65–90</td>
<td>65–90</td>
<td>66–95</td>
<td>66–93</td>
<td></td>
</tr>
</tbody>
</table>

Inclusion criteria:

- age ≥ 65 years
- officially confirmed caregiver status
- living at home
- normal cognition (geriatric evaluation)
- protein intake under 1.2 g/kgBW/d at baseline
- officially confirmed caregiver status
- living at home
- normal cognition (geriatric evaluation)
- age ≥ 65 years
- no diagnosed memory disorders (geriatric evaluation)
- not receiving home meals
- capable of filling out food diaries and questionnaires,
- no restricting diets (lactose free diet and gluten free diet acceptable) or illnesses that can prevent eating study meals (assessment by questionnaire and interview)
- able to move inside the house (with or without a rollator or wheelchair

5.2 Ethical considerations

Both the Care Nutrition (Studies I and II) and Power Meals (Studies III and IV) trials were approved by the Ethics Committee of the Hospital District of Southwest Finland. All participants provided informed consent. The design and purpose of the trial were disclosed, and the participants had the opportunity to drop out from the study at any point without a reason. Both studies were registered and described at the Australian New Zealand Clinical Trials Registry: the Care Nutrition trial Id: ACTRN12615001254583 and Power Meals trial Id: ACTRN12618000955213. The Care Nutrition study had funding from the National Institute for Health and Welfare (THL) Finland. The Power Meals trial was funded by Oy Karl Fazer Ab and Compass Group FS Finland Oy. The funders had no role in the study analysis.
5.3 Measurements

In both the Care Nutrition trial (Studies I and II) and the Power Meals trial (Studies III and IV), the study participants underwent a detailed assessment at study baseline and at final measurements, which are presented in the next chapters and in Table 8. In the Care Nutrition trial (Studies I and II), part of the baseline measurements were performed by trained nurses during caregivers’ health screenings at the healthcare centres of Pori Social and Health Services. The rest of the measurements were performed or instructed (food diary and laboratory tests) during the study nutritionist’s home visit. Final measurements were performed at participants’ homes by a trained nurse and the study nutritionist. In the Power Meals trial (Studies III and IV), baseline measurements were performed in participants’ homes (study nutritionist visit) and at the appointment with the study nurse and geriatrician at the main healthcare centre of Pori Social and Health Services. Final measurements were performed at participants’ homes by the study nurse and the nutritionist. In both trials (Studies I-IV), participants’ ability to participate in the study was evaluated by a geriatrician based on baseline measurements.

Table 8. Measurements obtained in Studies I-IV

<table>
<thead>
<tr>
<th></th>
<th>Care Nutrition trial</th>
<th>Power Meals trial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Study I</td>
<td>Study II</td>
</tr>
<tr>
<td><strong>Background information</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demographic data, medication etc.*</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>BMI</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>MMSE</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>GDS-15</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>ADL</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>IADL</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>AUDIT</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>SNAQ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SARC-F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory tests</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td><strong>Nutritional status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MNA</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Nutrient intake</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-day food record</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td><strong>Physical performance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPPB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand grip strength</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Five Times Sit to Stand Test</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Physical activity</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quality of life</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15D</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Intervention compliance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feedback of the dietary guidance</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Consumption of the intervention meals</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BMI: body mass index; MMSE: Mini Mental State Examination; GDS-15: Geriatric Depression Scale; ADL= Activities of Daily Living; IADL= Instrumental Activities of Daily Living; AUDIT= Alcohol Use Disorders Identification Test; SNAQ: Simplified Nutritional Appetite Questionnaire; SARC-F: Simple Questionnaire to Rapidly Diagnose Sarcopenia; MNA: Mini Nutritional Assessment; SPPB= Short Physical Performance Battery; 15D= Health-related quality of life square. *Analyzed from a structured questionnaire with open questions.
Background characteristics (Studies I-IV)
Background information (Studies I-IV) was assessed at baseline using a structured questionnaire with open questions (e.g. demographic data, medication). Anthropometric measurements were performed to assess participants’ height, weight and BMI. At baseline, food habits, special diets, ability to cook and shop groceries, and the use of supplements were assessed using questionnaire with open questions. Mini Mental State Examination (MMSE) was used to assess participants’s cognition (Folstein et al. 1975). In Studies III and IV, we reported categorical results, where the reference values are based on the Finnish Memory Experts Association (Sulkava et al. 2007): normal cognition 28-30, mildly impaired cognition 24-27, mild dementia, 18-23, average dementia, 12-17, and severe dementia <12 points. In Studies I-IV, we used the Geriatric Depression Scale (GDS-15) with reference values of 0–5 points no depression, 6–10 points mild or moderate depression, and 11–15 points severe depression (Friedman et al. 2005, Yesavage et al 1983). An open question was used to gather information on medication. In Studies I and II, we used the Katz index (Katz et al. 1963) to assess activities of daily living (ADL), where the result range between 0 and 6 points, with a higher score indicating better functioning. The Lawton-Brody questionnaire (Lawton & Brody 1969) was used to assess instrumental activities of daily living (IADL), where the result range between 0 and 8 points, with a higher score indicating better functioning. In Studies I and III, we assessed harmful alcohol use (alcohol consumption, drinking behaviours, and alcohol-related problems) by the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al. 1993), where a total score of 8 or more is an indicator of hazardous and harmful alcohol use and potential alcohol dependence. In Studies III and IV, we used the SNAQ (Simplified Nutritional Appetite Questionnaire) for nutritional appetite screening (Wilson et al. 2005) and the SARC-F (Simple Questionnaire to Rapidly Diagnose Sarcopenia) for sarcopenia screening (Malmström et al. 2016, Malmström & Morley 2013).

Mini Nutritional Assessment (Studies I – IV)
The Mini Nutritional Assessment (MNA) was used to screen nutritional status (Vellas et al. 1999). The MNA consists of 18 questions grouped into the four categories of anthropometry, general status, dietary habits, and self-perceived health and nutrition states. The reference values are as follows; >23.5 points normal nutritional status, 17-23.5 points at risk of malnutrition, and <17 points malnourished. The MNA is recommended for use because of its high inter-rater reliability and simplicity. It is currently recommended for grading the nutritional status of older persons worldwide (Guigoz 2006, Kondrup et al. 2003).

Energy and nutrient intake (Studies I – IV)
Intakes of energy, protein and other nutrients were analysed from three-day food records. Participants filled food records at baseline (before intervention
started) and at final measurements (in Study IV, home-delivered meals were still on). Participants were instructed to complete the food diaries at home as accurately as possible for three days, including one day of the weekend. Participants were encouraged to use measures (a scale, measuring cups, etc.) to give precise information about their eating. Phone calls were made to confirm the types and amounts of food being consumed, and to assess possible under- or overreporting if necessary.

The Finnish National Food Composition Database (Fineli) was used to calculate the average energy and nutrient intakes. The use of possible nutritional supplements, such as vitamins, were not taken into account in the calculations. To calculate the daily habitual protein intake, we used adjusted body weight depending on the participants’ BMI. The weight measured in the baseline measurements was used for the calculation. Actual body weight was adjusted if necessary to the nearest weight that would place the participant closer to the conventional healthy BMI in terms of protein intake since underweight persons need extra protein to build muscle tissue, while among overweight persons, the extra weight is adipose tissue (Berner et al. 2013). If the BMI was 20–30 kg/m², we used the actual weight, if under 20 kg/m², we adjusted the weight to match BMI 20, and if the BMI was above 30 kg/m², we adjusted the weight to match BMI 30. The protein intake per bodyweight is reported as g/kg adjusted bodyweight/d (g/kg aBW/d).

**Intervention compliance/feedback (Studies II and IV)**

In the Care Nutrition trial (Study II), feedback on the dietary guidance, nutrition care plan, and group meetings was gathered from the intervention group by structured postal questionnaire with open questions. In the Power Meals trial (Study IV), participants in the intervention groups completed a daily self-administered structured questionnaire reporting the average amount of meal components (protein source, side dish etc.) consumed of the delivered home meals. The participant completed the questionnaire which included separate question for each meal component. By checking the box, participants showed how much they ate of the meal components: a little over half, half, under half, or nothing. Based on the questionnaire, we analysed how often (%) participants ate all meal components (e.g. no leftovers).

**Physical performance (Studies I, III and IV)**

In Study I, we used the Five Times Sit-to-Stand Test to assess lower extremity muscle strength (Bohannon 2006). In Studies III and IV, physical performance was assessed with the Short Physical Performance Battery (SPPB). The SPPB consists of three subtests: the Five Times Sit-to-Stand Test, timed 4-m walk and 10-s balance tests (side-by-side, semi-tandem, and full-tandem) (Guralnik et al. 1994, Cruz-Jentoft et al 2019). Participants were instructed to sit in a regular height, straight-backed chair, with their feet touching the floor and to rise five times without the use of their arms as
support. The time to complete the five chair stands (standing up and sitting down as quickly as possible) was recorded in seconds. If participant was not able to do the test, the result was recorded as “missing” and if the participant tried to do the test but failed, 0 points were recorded. Test time exceeding the following cut-offs indicates worse than average performance: 11.4 s (60–69 years), 12.6 s (70–79 years), and 14.8 s (80–89 years) (Bohannon 2006). To assess walking speed, the participants walked four metres at their regular pace and the performance was recorded in seconds. The standing balance tests included tandem, semi-tandem and side-by-side standing, and the participants were timed until they moved, or 10 seconds had elapsed. Each test (sit-to-stand test, balance, walking speed) was scored from 0 to 4, and summed for a total score; 0–6 points represented poor physical performance, 7–9 points “at-risk” and >10 points high performance (Guralnik et al. 1994). In Studies I, III and IV, hand grip strength was assessed by using a Jamar Hydraulic Hand Dynamometer (Jamar Bolingbrook IL 60440-4989). Participants were asked to sit in a chair with a back support and fixed arm rests. The hand-grip strength of each hand was measured twice or three times. Maximal hand grip score was registered (Roberts et al 2011). In Study III, physical activity (PA) including mean daily time of moderate-to-vigorous physical activity (MVPA), steps, standing and mean time of sedentary behaviour (SB) comprising lying (not sleeping) and sitting were assessed with a hip-worn or wrist-worn accelerometer during seven days (UKK RM42, UKK Terveyspalvelut Oy, Finland) (Vähä-Yppä et al. 2015, Vähä-Ypyä et al. 2018). UKK Institute analysed the collected data with specific programme.

**Quality of life (Studies I- IV)**

Health-related quality of life was assessed by 15D instrument, which is a generic, 15-dimensional, self-administered questionnaire. It consists of the following 15 dimensions related to health-related quality of life; mobility, vision, hearing, breathing, sleeping, eating, speech, excretion (bowel habits and urination), usual activities, mental function, discomfort and symptoms, depression, distress, vitality and sexual activity. Each dimension has 5 ordinal levels. The respondent chooses from each dimension the level, which best describes her/his present health status. A set of utility or preference weights was used to generate the 15D score (single index number) representing the overall quality of life on a scale of 0–1, where 1 represents the best quality of life (Sintonen 2001).

**Laboratory tests (Study I)**

In the Care Nutrition trial (Study I), laboratory tests of plasma 25(OH)D vitamin, complete blood count (haemoglobin reported), plasma albumin, and serum prealbumin were conducted in the Satakunta Central Hospital laboratory (SataDiag, Finnish Accreditation Service, standards SFS-EN ISO/IEC 17025:2005, SFS-EN ISO 15189:2013). Haemoglobin was assessed using a photometric system, serum 25(OH)D vitamin levels using a
immunoluminometric system (Advia Centaur) that measures both ergocalciferol and cholecalciferol 25-hydroxylated metabolites, plasma albumin using a photometric (bromocresol purple method) system, and serum prealbumin using a photometric, immunochemical system.

**Geriatric evaluation (Studies I-IV)**

In the Care Nutrition trial (Studies I and II), geriatric evaluation was conducted based on the participant’s baseline measurement documents. An experienced geriatrician reviewed the documents and evaluated the ability to participate in the study. As part of the caregiver health screening, the geriatrician also recommended further examinations if needed in which case the nurse contacted the participant (e.g. to recommend a doctor’s appointment). In the Power Meals trial (Studies III and IV), every participant had a 30-min geriatrician appointment after baseline measurements, where an overall geriatric evaluation was conducted by the same geriatrician as in the Care Nutrition study. The geriatrician discussed the study with the participant and reviewed the participant’s self-filled questionnaires and the measurements obtained by the nutritionist and the study nurse. After reviewing the documents and meeting the participant, the geriatrician evaluated the participant’s ability to participate in the study. The geriatrician also recommended further examinations to the participant if needed.

**5.4 Randomization**

After baseline measurements and inclusion, the participants were randomly allocated to a study group according to a computer-generated, blocked randomization list. In the Care Nutrition trial (Studies I and II), participants were 1:1 allocated to the intervention (guidance group) or the control group, and in the Power Meals trial (Studies III and IV), the participants were 1:1:1 allocated to intervention 1 (protein group), intervention 2 (regular group), or the control group (if there were two participants from the same household, they were randomized to the same group). In both studies, a person unrelated to the study carried out the randomization.

**5.5 Interventions**

**Dietary guidance (Study IV)**

The Care Nutrition trial was a six-month intervention, that included tailored dietary guidance (1-2 hour home visit) and 2-4 group meetings, complemented with written material. The aim was to perform an intervention that could be implemented in real life at health care services. The main elements of the intervention are presented in Table 9.
During the six-month period, the intervention group (guidance group) was given tailored dietary guidance in participant’s homes on one occasion (1–2 hours). The study nutritionist visited the caregivers’ homes at the beginning of the six-month intervention. Dietary guidance was based on the participant’s nutritional status (MNA results), nutrient intake, background information, and on the discussion with the participant. Ideal protein intake was then calculated for each participant. A written nutritional care plan and other guidance material were given to each participant (Figure 4). The nutritional care plan and dietary guidance highlighted the positive factors in participants’ diets. A special focus was on protein sources and quantity of protein-rich products. The participants were given practical advice on how to improve their diet quality. Participants were encouraged to increase the use of good protein sources if needed. The nutritionist and the caregiver discussed personal nutritional aims, that were the recorded in the care plan. The main aims were usually related to finding easy and practical ways of increasing protein intake.

Each caregiver had the opportunity to participate in either group discussions (duration 1.5–2 h, 4 times,) or cooking courses (duration 2.5 h, 2 times) during the six-month intervention. The main aims of the group discussions were to provide peer support and social activity, and to reinforce the nutritional messages. The nutritionist guided the conversations, focusing on cooking and nutrition. The caregivers had the opportunity to discuss their situations at home. The cooking sessions included a short 15-minute guidance on healthy nutrition, and then dishes were prepared and enjoyed together (Figure 5). The guidance and the meals focused on protein-rich products and how to prepare tasty food. Traditional foods that were important to participants were also prepared. Cooking courses were held in the institutional kitchen of the local
Martha Organization, with the help of a domestic counsellor. In the control group, participants were given a booklet about healthy nutrition. Dietary guidance was offered after the final measurements.

Figure 5. Susanna Kunvik and participants in the cooking course.
Picture: Marika Virtanen/Porin perusturva

Table 9. Overview of the tailored nutritional intervention and the procedures followed in the control group in the Care Nutrition trial

<table>
<thead>
<tr>
<th>Main element</th>
<th>Nutritional intervention in the dietary guidance group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention duration</td>
<td>Six months</td>
<td>-</td>
</tr>
<tr>
<td>Tailored dietary guidance</td>
<td>A 1 to 2 -hour home visit at the beginning of the six-month intervention (study nutritionist). Dietary guidance was based on food diaries, baseline measurements and discussions with the participant.</td>
<td>After completion of the trial.</td>
</tr>
<tr>
<td>at home</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrition care plan</td>
<td>A four-page booklet, especially targeted to health promotion. Included personal feedback on each caregiver’s meal rhythm and intake of energy, protein, fibre and some vitamins. After the discussion dietary targets were written in the care plan.</td>
<td>After completion of the trial.</td>
</tr>
<tr>
<td>Written material</td>
<td>Different non-commercial booklets were handed out based on the guidance: general information about nutrition, good protein sources, hydration and special diets if needed.</td>
<td>Booklet on nutrition was sent after randomization to the control group.</td>
</tr>
<tr>
<td>Group meetings</td>
<td>Caregivers had a choice of group meetings during the intervention: cooking classes (two times) or group discussion (four times).</td>
<td>-</td>
</tr>
<tr>
<td>Telephone contact</td>
<td>Food records were checked at the beginning of the intervention and a follow-up call was made after 3 months. A feedback call gathered after the intervention. Participants had the opportunity to call the study nutritionist, if necessary.</td>
<td>Food records were checked.</td>
</tr>
</tbody>
</table>
Home-delivered meals (Study IV)
The Power Meals trial consisted of two intervention arms. Participants in the intervention groups (protein group and regular group) were offered one home-delivered meal every day for eight weeks (total 53 days), and participants in the protein group also received one protein-rich snack and 2 slices of protein-rich bread daily. An overview of the interventions and meal contents is provided in Table 10. A one-week sample menu and more detailed nutritional content of the intervention meals are presented in the original Study IV article.

In both interventions, menus were designed, prepared and delivered in cooperation with one of the largest food service providers in Finland. Finnish nutritional recommendations were used to develop the meals. The two menus in protein group and regular group were rotating (six weeks) and contained 42 different meals (Figure 6). Every meal contained a main dish, side dishes, warm vegetables/salad, and dessert. Meals in the regular group group were traditional home meals, that the food service company has provided for many years to customers.

In protein group, protein-rich meals were chosen from the food service’s meal selection, such that the protein-rich menu contained more meals with high protein content than in regular group. Protein-rich snacks and bread were chosen to the protein group menu from the selection, and some snacks were specially developed for this study (Figure 7). Since meals, snacks, and bread were chosen "protein-consciously", the protein content of the offered meal service increased. The main ingredients of the protein-rich meal, snack, and bread were naturally protein-rich; meat, fish, eggs, and soybeans were often used as ingredients, and most of the snacks were naturally protein-rich dairy based products. Breads were whole grain and often contained seeds, increasing the protein content. Artificial protein enrichments were not used. Compared with regular group, participants in protein group were offered approximately 27.5 g/d more protein from the intervention meals, where 4.3 g came from the main meals, 16.0 g from protein-rich snacks, and 7.2 g from bread.

Main meals (not snacks) were prepared with the cook and chill method at a catering kitchen. Meals, snacks and bread were delivered cold twice a week by the same driver. The need for a basic special diet, such as a lactose-free or gluten-free diet, was ascertained by interview before starting the meal service. A printed meal menu was delivered with each of the meals, and participants were instructed to follow the menu as planned. Participants were instructed on how to store and heat the meals, and when to eat the meals. During the intervention, participants were able to contact the meal service company or the study nutritionist to ask for guidance regarding the meal service.
In the control group, participants were advised to continue eating as usual (their own normal diet). As a gesture for participating in the study, a 2-week complimentary home meal service (regular) was offered after the final measurements.

Figure 6. Examples of the main meals. Pictures: Compass Group

Figure 7. Study snacks; cloudberry quark, caramel quark and salmon pasty. Pictures: Compass Group.
Table 10. Overview of the interventions and meal contents, and the procedures in the control group in the Power meals trial.

<table>
<thead>
<tr>
<th>Description</th>
<th>Protein group</th>
<th>Regular group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protein-rich home meal, snack, and two slices of bread for 7 days/week, 8 weeks (total of 53 days). Delivered cold two times/week.</td>
<td>Regular home meal for 7 days/week, 8 weeks (total of 53 days). Delivered cold two times/week.</td>
<td>No meal service, own usual diet. Two-week complimentary home meals after final measurements.</td>
</tr>
</tbody>
</table>
| Meal content                         | **Home meal:** varying main dish naturally rich in protein (meat/fish/beans etc.), side dishes, warm vegetables/salad, dessert  
Snack: protein-rich snacks (quark/yoghurt/omelette, etc.)  
Bread: naturally protein-rich bread, 2 slices/day (seed bread/rye bread/oat bread) | **Home meal:** varying main dish, side dishes, warm vegetables/salad, dessert | - |

| Amount of energy, mean (SD) kcal     | **Home meal:** 667 (129)  
Snack: 131 (34)  
Bread (2 slices): 184 (20) | **Home meal:** 614 (153) | - |
| Amount of protein/meal, mean (SD) g  | **Home meal:** 25.2 (4.2)  
Snack: 17.2 (4.5)  
Bread (2 slices): 7.8 (2.1) | **Home meal:** 21.4 (5.1) | - |
| Portion size, mean (SD) g            | **Home meal:** 518 (59)  
Snack: 180 (39)  
Bread (2 slices): 68 (9) | **Home meal:** 516 (58) | - |
| Guidance/instructions                | Instructions/recommendation on when to eat the meals (lunchtime, snack (afternoon) and bread (lunchtime and afternoon) and how to heat and store the meals. Participants were advised to follow their usual dietary habits for other meals and snacks. | Instructions/recommendation on when to eat the meals (lunchtime) and how to heat and store the meals. Participants were advised to follow their usual dietary habits for other meals and snacks. | Participants were advised to follow their usual dietary habits during the study. |

The mean contents of energy and protein, and portion sizes are calculated from the standard recipes of the meal service provider.

### 5.6 Statistical methods

The results are presented as means with standard deviation (SD) or as counts with percentages. The 95% confidence intervals are presented for the main outcomes. P-values less than 0.05 were considered statistically significant. In Studies I and III, results are presented from baseline measurements (cross-sectional studies) in more detail. In Studies II and IV, results are presented from baseline and final measurements describing the difference in changes after interventions (RCT studies). The results are presented for participants, who completed the trial.

In Studies I and II, statistical differences between groups were determined by T-tests, the Mann Whitney U-test, the Chi-square test, or Fisher’s exact test, whichever was appropriate. In Study III, statistical differences between groups (home care clients, caregivers and care recipients) were determined using the
Pearson Chi-square test for categorical variables, One-way analysis of variance (ANOVA) for normally distributed continuous variables and the Kruskal-Wallis test for non-normally distributed variables. In Study IV, Statistical comparisons between groups were done using the ANOVA or Chi-square test.

In Studies I and III, associations of nutritional status and nutrient intake were analysed by linear regression models (the Enter method). In Study I, the model was adjusted for age and BMI, and in Study III the model was adjusted for age and sex. The results are presented as standardized beta coefficients (β). In Study II, we analysed the changes in protein intake among participants who completed the whole trial and had protein intake of under 1.2 g/kg aBW/d at baseline (since the main target was no increase protein intake to recommended levels of ≥ 1.2 g/kg/d). Special attention was given to male caregivers based on subgroup analysis. The main outcome measures were subjected to an analysis of covariance (ANCOVA); age, gender, BMI, and value at baseline were added to the model as covariates. In case of violation of assumptions (e.g. nonnormality), a bootstrap-type test was used. In Study IV, the main outcome measures were subjected to analysis of covariance (ANCOVA); the values at baseline were added to the model as covariates. The bootstrap method was used when the theoretical distribution of the test statistics was unknown or in case of a violation of assumptions (e.g. nonnormality). Hommel’s adjustment was applied to correct levels of significance for multiple testing, if appropriate. The normality of variables was evaluated graphically and with the Shapiro-Wilk W test.

In Studies I and II, statistical analyses were carried out using SPSS version 22.0 (SPSS, Inc., Chicago, IL, USA), Study III using SPSS version 25.0 (IBM Corp., Armonk, NY, USA), and in Studies II and IV, Stata 15.1 (StataCorp LP; College Station, TX, USA).
6 RESULTS

6.1 Baseline characteristics

The Care Nutrition trial (Study I)
Alltogether 79 older (≥65 years) community-dwelling caregivers (49 females, 30 males) participated in the study, 69 caregivers (39 females, 30 males) of whom completed the study (drop-out rate 13%).

Table 11 presents the baseline characteristics of the participants. The mean age was 73.7 years, and most (84%) of the caregivers were spousal caregivers. The mean cognition points were normal (mean MMSE score 27.4) and they had good quality of life (mean 15D score 0.9). Most of the caregivers had good physical functioning according to ADL and IADL scores. Male caregivers had worse IADL scores than women (p=0.008). According to GDS-15, one in ten suffered from mild or moderate depression. According to AUDIT, 13% (n=4) of the males scored >8 points, indicating harmful patterns of alcohol consumption or drinking behaviours.

The Power Meals trial (Study III)
Alltogether 78 older (≥65 years) community-dwelling individuals (47 female, 31 male) participated in the Power Meals trial, 67 participants (40 females, 27 males) of whom completed the study (drop out rate 14%). Total of 32 (41%) participants were home care clients, 23 (29%) caregivers, and 23 (29%) care recipients.

Table 11 presents the baseline characteristics of the participants. The mean age of all participants was 78.2 years (SD 7.4). Home care clients were older than caregivers or care recipients. The mean MMSE-score was 25.3, and caregivers had better cognition than other groups. According to GDS-15, one in four participants suffered from mild or moderate depression. Caregivers had less depression than participants in the other groups. Number of medication was highest among home care clients. According to SARC-F, over half (59%) of the participants had increased risk for sarcopenia (≥4 points). Caregivers had significantly lower risk. Over one-third (37%) of all participants scored under 14 points in the SNAQ questionnaire indicating poor appetite. According to AUDIT, 6.4% of participants scored >8 AUDIT points, indicating hazardous and harmful alcohol use. According to SPPB, almost half (47%) of the participants had poor physical performance (≤ 6 points) and 24% were at risk (7–9 points). Caregivers had higher SPBB points than care recipients or home care clients (p<0.001). According to accelerometer results, caregivers were physically more active (p=0.008) than care recipients and home care clients, and had more steps (<0.001) and standing (p<0.001) during the day.
Table 11. Background characteristics of the participants in the Care Nutrition trial and the Power Meals trial

<table>
<thead>
<tr>
<th></th>
<th>Care Nutrition trial (Study I)</th>
<th>Power Meals trial (Study III)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All caregivers (n=79)</td>
<td>Female caregivers (n=49)</td>
</tr>
<tr>
<td>Age, mean (SD)</td>
<td>73.7 (6.2)</td>
<td>72.9 (5.9)</td>
</tr>
<tr>
<td>Education years, mean (SD)</td>
<td>10.1 (3.6)</td>
<td>10.1 (4.0)</td>
</tr>
<tr>
<td>BMI kg/m², mean (SD)</td>
<td>28.1 (4.5)</td>
<td>27.9 (4.0)</td>
</tr>
<tr>
<td>MMSE points, mean (SD)</td>
<td>27.4 (2.4)</td>
<td>27.6 (2.3)</td>
</tr>
<tr>
<td>Depression (GDS-15)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean score, (SD)</td>
<td>2.8 (2.6)</td>
<td>3.1 (2.6)</td>
</tr>
<tr>
<td>Mild/moderate depression (%)</td>
<td>10.1</td>
<td>10.2</td>
</tr>
<tr>
<td>Severe depression (%)</td>
<td>1.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Number of medications %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excessive polypharmacy, over 10/d</td>
<td>4.0</td>
<td>4.3</td>
</tr>
<tr>
<td>Polypharmacy, 5-10 / d.</td>
<td>29.3</td>
<td>28.3</td>
</tr>
<tr>
<td>No polypharmacy 0-4 / d.</td>
<td>66.7</td>
<td>67.4</td>
</tr>
<tr>
<td>Quality of life, 15D score, mean (SD)</td>
<td>0.9 (0.01)</td>
<td>0.9 (0.08)</td>
</tr>
<tr>
<td>ADL points, mean (SD)</td>
<td>5.9 (0.3)</td>
<td>5.9 (0.3)</td>
</tr>
<tr>
<td>IADL points, mean (SD)</td>
<td>7.9 (0.3)</td>
<td>8.0 (0.3)</td>
</tr>
<tr>
<td>SPPB points mean (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Five Times Sit-to-Stand Test, seconds, mean (SD)</td>
<td>13.8 (3.3)</td>
<td>14.0 (3.4)</td>
</tr>
<tr>
<td>Hand-grip strength, dominant hand (kg), mean (SD)</td>
<td>30.9 (10.8)</td>
<td>25.8 (5.9)</td>
</tr>
<tr>
<td>Steps per day, mean (SD)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

69
<table>
<thead>
<tr>
<th></th>
<th>Care Nutrition trial (Study I)</th>
<th>Power Meals trial (Study III)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All caregivers (n=79)</td>
<td>All (n=78)</td>
</tr>
<tr>
<td></td>
<td>Female caregivers (n=49)</td>
<td>Home care clients (n=32)</td>
</tr>
<tr>
<td></td>
<td>Male caregivers (n=30)</td>
<td>Caregivers (n=23)</td>
</tr>
<tr>
<td></td>
<td>P-value</td>
<td>P-value</td>
</tr>
<tr>
<td>Moderate-to-vigorous physical activity h/d, mean (SD)</td>
<td>-</td>
<td>0.2 (0.3)</td>
</tr>
<tr>
<td>Sedentary behaviour, h/d, mean (SD)</td>
<td>-</td>
<td>11.4 (2.6)</td>
</tr>
<tr>
<td>Standing, h/d, mean (SD)</td>
<td>-</td>
<td>0.81 (0.82)</td>
</tr>
<tr>
<td>AUDIT, points, mean (SD)</td>
<td>2.2 (2.9)</td>
<td>1.8 (2.8)</td>
</tr>
<tr>
<td>SARC-F points, mean (SD)</td>
<td>-</td>
<td>4.0 (2.8)</td>
</tr>
<tr>
<td>SNAQ points, mean (SD)</td>
<td>-</td>
<td>13.9 (2.0)</td>
</tr>
</tbody>
</table>

Differences between the characteristics were tested using the Chi Square test or Fisher’s exact test as appropriate, for categorical variables; the Mann Whitney U-test for non-normally distributed continuous variables and Student’s T-test for normally distributed continuous variables.
6.2 Nutritional status at baseline (Studies I and III)

MNA (Studies I and III)
In the Care Nutrition trial (Study I), 19% (n=15) of the older caregivers were at risk of malnutrition and one person (1.3%) suffered from malnutrition, according to the MNA test (Table 12). Female caregivers were more likely to be at risk of malnutrition than males (27% vs. 7%, p=0.026). The MNA test showed that females suffered more psychological stress or acute illnesses than males, although the difference just reached above statistical significance (p=0.056). In the Power Meals trial (Study III), almost one-third (32%, n=25) of participants were at risk of malnutrition and two participants (3%) suffered from malnutrition. No statistical difference existed between the sexes. Nutritional status was worse for home care clients and care recipients than for caregivers (p=0.001, Table 12). When comparing the two different samples of caregivers, the prevalence of the risk of malnutrition was quite similar; 19% (Study I) and 13% (Study III).

In both studies (Studies I and III), nutritional status was negatively associated with symptoms of depression (GDS-15, p<0.001 and 0.015) and the number of medications (p<0.001 and 0.017) (Table 13). Also in both studies, a positive association existed between nutritional status and quality of life (15D, p=0.026 and p=0.018). Additionally, in the Power Meals trial (Study III), higher MMSE score (p=0.003), greater hand-grip strength (p<0.001), better appetite (SNAQ, p<0.001), a higher points in SPPB (p=0.001), higher number of daily steps (p=0.010) and standing (p=0.001) were associated with better nutritional status. Negative association was present with higher SARC score (p=0.001).

Laboratory tests (Study I)
In the Care Nutrition trial (Study I), caregivers’ mean serum 25(OH)D levels was 80.8 nmol/l. A total of 73% took a vitamin D supplement; females more likely than males (82% vs. 60%, p=0.035). The use of a vitamin D supplement was positively related to serum 25(OH) D levels (84.7 nmol/l supplement users vs. 69.7 nmol/l non-users, p=0.035). Mean haemoglobin was 138 g/l, and the levels were positively associated with nutritional status (p=0.031, beta=0.259). Results are presented in more detail in the original Study I article.
Table 12. Nutritional status (MNA) of participants

<table>
<thead>
<tr>
<th></th>
<th>CareNutrition trial (Study I)</th>
<th>Power Meals trial (Study III)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All (n=79)</td>
<td>Male (n=30)</td>
</tr>
<tr>
<td>MNA points, mean (SD)</td>
<td>25.7 (2.6)</td>
<td>26.0 (2.8)</td>
</tr>
<tr>
<td>Normal nutritional status, &gt;23.5 p. %</td>
<td>79.7</td>
<td>90.0</td>
</tr>
<tr>
<td>Risk of malnutrition, 17-23.5 p. %</td>
<td>19.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Malnourished, &lt;17 p. %</td>
<td>1.3</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Table 13. Associations between nutritional status (MNA) and different characteristics

<table>
<thead>
<tr>
<th></th>
<th>CareNutrition trial (Study I), n=79</th>
<th>Power Meals trial (Study III), n=78</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β-coefficient</td>
<td>p-value</td>
</tr>
<tr>
<td>Cognition (MMSE)</td>
<td>0.015</td>
<td>0.905</td>
</tr>
<tr>
<td>Number of warm meals/day</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Medication*</td>
<td>-0.452</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Quality of life (15D)</td>
<td>0.336</td>
<td>0.026</td>
</tr>
<tr>
<td>Depression symptoms (GDS)</td>
<td>-0.487</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Appetite (SNAQ)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Risk for sarcopenia (SARC)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Physical Performance (SPPB)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Number of steps</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Hand-grip strength</td>
<td>0.106</td>
<td>0.377</td>
</tr>
<tr>
<td>Moderate-to-vigorous physical activity</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Standing</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Associations were analysed by linear regression models (the Enter method) adjusted for age and BMI in the Care Nutrition study and for age and gender in Power Meals study. The results are presented as standardized beta coefficients (β). P-values less than 0.05 were considered statistically significant. Medication is analysed as a continuous variable in the Care Nutrition study and as a dummy-variable (0 or 1) in the Power Meals study.
6.3 Energy and nutrients at baseline (Studies I and III)

6.3.1 Energy intake (Studies I and III)
In the Care Nutrition trial (Study I), caregivers’ mean energy intake was 1610 kcal/d at baseline (Table 14). Almost half (47%) had an energy intake of under 1500 kcal/d. Males had a higher energy intake than females (1798 kcal vs. 1494 kcal, p=0.002). Energy intake was higher (1707 kcal/d vs. 1418 kcal/d) among females who were at risk of malnutrition (MNA <23.5 points) compared to females without risk. In the Power Meals trial (Study III), participants’ mean energy intake was 1546 kcal/d (SD 499), and half (51%) of the participants did not reach 1500 kcal/d. Home care clients received less energy than caregivers or care recipients (p=0.022).

In both studies (Studies I and III), better nutritional status (p<0.001 and p<0.001) and greater hand-grip strength (p<0.001 and p=0.003) were associated with higher energy intake (Table 15). In Study III, better appetite (SNAQ, p<0.001), higher number of daily steps (p<0.001), higher MVPA time (p<0.001), standing (p=0.014), and number of warm meals per day (p=0.023) were also associated with higher energy intake.

6.3.2 Protein intake (Studies I and III)
In the Care Nutrition trial (Study I), mean protein intake was 69.2 g/d and 1.0 g/kg aBW/d per adjusted bodyweight (Table 14). Females had a greater protein intake calculated as energy (E%) than males (18 E% vs. 17 E%, p=0.045). In the Power Meals trial (Study III), the mean protein intake was 65.7 g/d and 0.90 g/kg aBW/d. Four out of five participants in both studies (Study I: 80%, Study III: 82%) did not consume the recommended protein level of ≥1.2 g/kg aBW/d.

In Study I, no significant associations between protein intake and different variables were found, when looking at the whole sample. Among male caregivers, a higher total AUDIT score (p=0.012, $\beta$=-0.454), indicating increased alcohol consumption, was associated with a lower protein intake, and greater hand-grip strength (p=0.031, $\beta$=0.433) was associated with a higher protein intake. In Study III, greater hand-grip strength (p=0.014), better appetite (SNAQ, p<0.001), better nutritional status (p=0.031), higher number of daily steps (p=0.001), higher daily MVPA time (p=0.002), standing (p=0.015) and number of warm meals per day (p=0.015) were associated with higher protein intake (Table 15). Higher risk of sarcopenia (SARC) was associated with lower intake of protein (p=0.025).
6.3.3 Other nutrients (Studies I and III)

In the Care Nutrition trial (Study I), dietary fibre (mean 19.8 g/d), folate (mean 208 µg/d) and vitamin D (mean 9.3 µg/d) intakes were insufficient (Table 14). Of participants, 84% did not reach the recommended daily intake of dietary fibre, folate (95%), or vitamin D (67%). In the Power Meals trial (Study III), fibre, potassium, iron, folate, and vitamin E were lower than recommended for this age group. Dietary intake of vitamin D was insufficient among ≥ 75-year-olds, who have a higher recommended level than younger people (20 µg vs. 10 µg/d). Most of the participants (94 %) received saturated fatty acids of at least 10 E% (mean intake 14 E%) which is more than recommended. More detailed results for nutrient intake can be seen in the original Study III article.
Table 14. Energy and nutrient intake of participants.

<table>
<thead>
<tr>
<th>Nutrient intake per day, mean (SD)</th>
<th>CareNutrition trial (Study I)</th>
<th>Power Meals trial (Study III)</th>
<th>Recom-</th>
<th>mendation*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All (n=79) Female (n=49) Male (n=30) p-value</td>
<td>All (n=78) Home care clients (n=32) Caregivers (n=23) Care recipients (n=23) p-value</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy, kcal</td>
<td>1610 (424) 1494 (377) 1798 (434) 0.002</td>
<td>1546 (499) 1364 (327) 1710 (507) 1637 (617) 0.022</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Protein, g</td>
<td>69.2 (17.9) 66.3 (16.3) 73.9 (19.6) 0.069</td>
<td>65.7 (23.0) 59.0 (16.7) 71.9 (20.2) 68.8 (30.6) 0.092</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Protein, E%</td>
<td>17.4 (3.1) 18.0 (2.9) 16.6 (3.1) 0.045</td>
<td>17.1 (2.7) 17.3 (2.4) 17.0 (2.4) 16.7 (3.5) 0.741</td>
<td>15–20 E%</td>
<td></td>
</tr>
<tr>
<td>Protein, g/kg aBW/d</td>
<td>1.0 (0.3) 1.0 (0.3) 0.9 (0.2) 0.378</td>
<td>0.90 (0.31) 0.85 (0.27) 1.02 (0.33) 0.86 (0.34) 0.109</td>
<td>1.2–1.4 g/kg/d</td>
<td></td>
</tr>
<tr>
<td>Fiber, g</td>
<td>19.8 (6.0) 19.2 (6.0) 20.7 (5.9) 0.269</td>
<td>16.8 (7.4) 13.8 (5.3) 20.1 (8.2) 17.5 (7.7) 0.008</td>
<td>&gt;25 g/d females &gt;35 g/d males</td>
<td></td>
</tr>
<tr>
<td>Calcium, mg</td>
<td>888.9 (338.8) 829.5 (287.1) 985.9 (395.6) 0.151</td>
<td>920.2 (397.6) 911.9 (379.0) 916.1 (367.6) 937.1 (464.0) 0.853</td>
<td>800 mg/d</td>
<td></td>
</tr>
<tr>
<td>Iron, mg</td>
<td>9.1 (2.6) 8.7 (2.5) 9.9 (2.7) 0.047</td>
<td>7.8 (2.4) 7.2 (2.1) 8.8 (2.1) 7.8 (2.9) 0.053</td>
<td>9 mg/d</td>
<td></td>
</tr>
<tr>
<td>Potassium, g</td>
<td>3.4 (0.8) 3170.4 (690.1) 3643.1 (922.3) 0.024</td>
<td>3.1 (1.0) 2.8 (0.8) 3.3 (0.77) 3.2 (1.3) 0.068</td>
<td>3.1 g/d females 3.5 g/d males</td>
<td></td>
</tr>
<tr>
<td>Folate, µg</td>
<td>208.1 (69.8) 203.3 (68.2) 216.0 (72.7) 0.374</td>
<td>206.6 (81.6) 183.1 (84.5) 231.2 (74.9) 214.6 (78.1) 0.013</td>
<td>300 µg/d</td>
<td></td>
</tr>
<tr>
<td>Vitamin C, mg</td>
<td>87.7 (76.5) 99.2 (92.6) 68.8 (30.5) 0.081</td>
<td>84.0 (57.2) 53.3 (30.2) 105.5 (56.4) 105.3 (68.2) &lt;0.001</td>
<td>75 mg/d</td>
<td></td>
</tr>
<tr>
<td>Vitamin D, µg</td>
<td>9.3 (5.3) 8.8 (5.0) 10.1 (5.8) 0.342</td>
<td>10.0 (5.5) 9.0 (5.0) 10.8 (4.6) 10.6 (7.0) 0.389</td>
<td>10 µg/d &lt; 75 years 20 µg/d ≥ 75 years</td>
<td></td>
</tr>
<tr>
<td>Vitamin E, mg</td>
<td>8.4 (3.3) 8.3 (3.8) 8.7 (2.5) 0.249</td>
<td>7.7 (3.6) 5.8 (2.2) 9.4 (3.7) 8.6 (4.1) &lt;0.001</td>
<td>8 mg/d females 10 mg/d males</td>
<td></td>
</tr>
</tbody>
</table>

Table 15. Associations with different characteristics between energy (kcal/d) and protein (g/kg aBW/d) intake

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>CareNutrition trial (Study I), n=79</th>
<th>Power Meals trial (Study III), n=78</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Energy intake</td>
<td>Protein intake</td>
</tr>
<tr>
<td></td>
<td>β-coefficient</td>
<td>p-value</td>
</tr>
<tr>
<td>Cognition (MMSE)</td>
<td>0.122</td>
<td>0.317</td>
</tr>
<tr>
<td>Hand-grip strength</td>
<td>0.423</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Physical Performance (SPPB)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Nutritional status (MNA)</td>
<td>0.998</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Appetite (SNAQ)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Risk for sarcopenia (SARC)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Depression symptoms (GDS)</td>
<td>-0.057</td>
<td>0.629</td>
</tr>
<tr>
<td>Quality of life (15D)</td>
<td>-0.035</td>
<td>0.818</td>
</tr>
<tr>
<td>Number of steps</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Moderate-to-vigorous physical activity</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Standing</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Number of warm meals/day</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Number of snacks/day</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

Associations were analysed by linear regression models (the Enter method) adjusted for age and BMI in the Care Nutrition study and for age and gender in the Power Meals study. The results are presented as standardized beta coefficients (β). *P-values less than 0.05 were considered significant. Medication is analysed as a continuous variable in the Care Nutrition study and as a dummy-variable (0 or 1) in the Power Meals study.
6.4 Effectiveness of dietary guidance (Study II)

In the Care Nutrition trial, a total of 69 caregivers completed the trial. Of the participants, 55 (n=28 guidance group, n=27 control group) had a protein intake of under 1.2 g/kg aBW/d at baseline (sample in the analysis of the intervention effectiveness, Study II). In this sample (n=55), most were spousal caregivers, and 46% were male (n=12 male guidance group, n=13 male control group). Most (86%) of the caregivers had a good nutritional status (MNA >23.5). Of all caregivers, 76% prepared their family meals themselves, but only half (50%) of the males (difference between females, p=0.001). Male caregivers had lower IADL scores than female caregivers, indicating weaker instrumental activities of daily living (7.8 points vs. 8.0 points, p=0.003). In the original Study II article, the baseline characteristics of study completers are presented in more detail.

Energy and protein intake

After six months, the mean change in energy intake was +102 (SD 254) kcal/d in the guidance group and +37 (SD 430) kcal/d in the control group, with no statistical difference between the groups (p=0.49), (Figure 8). However, the increase was significant within the guidance group (p=0.043). Among males, energy intake increased significantly in the guidance group by 97 (SD 254) kcal/d and decreased in the control group by -192 (SD 426) kcal/d (p = 0.05). Energy intakes in final measurements were thus 1655 kcal/d in guidance group and 1608 kcal/d in control group (at baseline, control group had greater energy intake, p=0.004). The mean change in the protein intake was +0.10 (SD 0.2) g/kg aBW/d in the guidance group and in the control group +0.04 (SD 0.2) g/kg aBW/d (Figure 9). There were no significant differences between the groups (p=0.26), but the increase within the guidance group was significant; 0.86 (SD 0.17) g/kg aBW/d to 0.96 (SD 0.25) g/kg aBW/d (p=0.038). There was a significant difference (p=0.007) in the change in protein intake between the two groups of male caregivers. In the male guidance group, the increase was 0.11 (SD 0.22) g/kg aBW/d and in the male control group, protein intake decreased -0.07 (SD 0.19) g/kg aBW/d. Total intake in the male guidance group was thus 1.0 g/kg aBW/d at the final measurement, compared with 0.72 g/kg aBW/d in the control group.

Feedback of the intervention

Among the guidance group, 15 participants (9 females, 6 males) chose the cooking courses, 11 (6 females, 5 males) participants group discussions and two of the participants did not attend groups. According to the feedback gathered post-intervention, 70% of caregivers (males 83.3%) in the guidance group found the nutritionist’s home visit useful; the corresponding figures for dietary guidance were 75% and 86%. Among participants who participated group guidance, 63% (64% males) considered them to be useful and 29% (36% males) partly useful. There were no statistical differences between males and females in the feedback.
Figure 8. Mean levels of energy intake and changes from baseline to six months among participants with protein intake $\geq 1.2 \text{ g/kg aBW/d}$. Statistical test were performed between guidance group and control group; adjusted for age, gender, BMI and value at baseline.

Figure 9. Mean levels of protein intake and changes from baseline to six months among participants with protein intake $\geq 1.2 \text{ g/kg aBW/d}$. Statistical test were performed between guidance group and control group; adjusted for age, gender, BMI and value at baseline.
6.5 Effectiveness of the home-delivered meals (Study IV)

In the Power Meals trial (Study IV), a total of 67 participants (n=22 protein group, n=24 regular group, n=21 control group) completed the trial. No differences were present in baseline characteristics between those who dropped out (n=11) and study completers (n=67), except for sarcopenia screening test (SARC), where participants who dropped out had higher points than study completers (p=0.025, 5.6 p. vs. 3.7 p.). Baseline characteristics of the study completers are shown in the original Study IV article.

Energy, protein and other nutrient intakes
After eight weeks, the mean change in energy intake was +185 kcal/d in the protein group, +155 kcal/d in the regular group and +7 kcal/d in the control group. No statistical difference existed (p=0.15) between groups (Table 16).

A significant difference emerged between the groups (protein group/regular group, protein group/control group) in changes in total protein intake (g/d) and protein intake per bodyweight (g/kg aBW/d) (Table 16). In the total protein intake, it increased by 9.4 g/d in the protein group and decreased by -2.7 g/d in regular group and control group. In the protein intake per body weight, it increased by 0.11 g/kg aBW/d in the protein group and decreased in the other groups: regular group -0.02 g/kg aBW/d and control group -0.04 g/kg aBW/d. Only one third (27%) of the participants in protein group, 13% in regular group and 5% in control group reached 1.2 g/kg aBW/d as recommended.

There was also a significant difference in calcium intake between protein group and control group, where the intake increased in protein group by 169.9 mg/d and decreased in the control group by 123.8 mg/d (Table 16). Salt intake decreased in both intervention groups compared with control group: 2330.9 mg/d in protein group and 2371.9 mg/d in regular group. Also, saturated fat intake increased significantly in both intervention groups compared with control group: 4.6 g/d in protein group and 7.8 g/d in regular group

Physical performance and quality of life
There was a significant difference in the Sit-to-Stand Test between protein group and control group, where protein group showed a greater improvement: -4.8 s in protein group and -2.7 s in control group (Table 16). No differences were present between groups in the SPPB total score, balance points, 4-m walk, or hand grip strength. There were no differences between groups in the total 15D score (Table 16). Significant differences emerged between groups at the final measurements in two 15D dimensions: protein group showed greater improvement in excretion and usual activities (detailed results in Study IV).
Table 16. Baseline and changes at the 8-week follow-up in nutrient intake, physical performance and quality of life among participants in different groups

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Baseline</th>
<th>Change from baseline to final measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protein group (n=22) mean (SD)</td>
<td>Regular group (n=24) mean (SD)</td>
</tr>
<tr>
<td></td>
<td>mean (SD)</td>
<td>mean (SD)</td>
</tr>
<tr>
<td>Energy, kcal</td>
<td>1582 (564)</td>
<td>1581 (476)</td>
</tr>
<tr>
<td></td>
<td>(12 to 358)</td>
<td>(-34 to 344)</td>
</tr>
<tr>
<td></td>
<td>Total protein, g/d</td>
<td>65.4 (23.5)</td>
</tr>
<tr>
<td></td>
<td>(1.0 to 17.8)</td>
<td>(-10.8 to 5.3)</td>
</tr>
<tr>
<td></td>
<td>Protein, g/kg abW/d</td>
<td>0.92 (0.38)</td>
</tr>
<tr>
<td></td>
<td>(0.01 to 0.02)</td>
<td>(-0.14 to 0.08)</td>
</tr>
<tr>
<td></td>
<td>Salt, mg/d</td>
<td>6209.9 (2163.0)</td>
</tr>
<tr>
<td></td>
<td>(2998 to -1664)</td>
<td>(-3399 to -1345)</td>
</tr>
<tr>
<td></td>
<td>Calcium, mg/d</td>
<td>863.4 (463.2)</td>
</tr>
<tr>
<td></td>
<td>(26 to 314)</td>
<td>(-137 to 92)</td>
</tr>
<tr>
<td></td>
<td>Saturated fat, g/d</td>
<td>24.9 (11.5)</td>
</tr>
<tr>
<td></td>
<td>(1.0 to 8.2)</td>
<td>(1.9 to 13.7)</td>
</tr>
<tr>
<td>Physical performance</td>
<td>SPPB total score</td>
<td>8.1 (3.1)</td>
</tr>
<tr>
<td></td>
<td>(0.4 to 1.9)</td>
<td>(0.0 to 1.3)</td>
</tr>
<tr>
<td></td>
<td>SPPB sit-to-stand test, s</td>
<td>16.5 (8.7)</td>
</tr>
<tr>
<td></td>
<td>(6.8 to -2.7)</td>
<td>(-6.6 to 0.6)</td>
</tr>
<tr>
<td></td>
<td>SPPB balance points</td>
<td>3.4 (1.0)</td>
</tr>
<tr>
<td></td>
<td>(0.2 to 0.8)</td>
<td>(-0.1 to 0.8)</td>
</tr>
<tr>
<td></td>
<td>SPPB 4-m walk, s</td>
<td>5.0 (2.3)</td>
</tr>
<tr>
<td></td>
<td>(0.6 to 0.2)</td>
<td>(-0.5 to 0.7)</td>
</tr>
<tr>
<td></td>
<td>Hand-grip strength, kg</td>
<td>28.8 (8.8)</td>
</tr>
<tr>
<td></td>
<td>(0.2 to 1.74)</td>
<td>(-1.5 to 1.2)</td>
</tr>
<tr>
<td>Quality of life</td>
<td>15D-score</td>
<td>0.82 (0.13)</td>
</tr>
<tr>
<td></td>
<td>(0.02 to 0.05)</td>
<td>(-0.05 to 0.03)</td>
</tr>
</tbody>
</table>

Difference between the baseline results of different groups were tested using the one-way ANOVA analysis of variance for normally distributed continuous variables and the Kruskal-Wallis test for non-normally distributed variables. Changes after intervention were tested using Bootstrap ANCOVA (baseline as covariate). Hommel’s multiple comparison procedure was used to correct significance levels for post hoc testing (p<0.05). P-values show whether a difference existed between groups and information in parentheses reveal which groups differed; I=protein group, II=regular group, C=control group. SPPB=Short Physical Performance Battery, 15D=measurement for quality of life.
**Compliance with study meals**

In the Power Meals trial (Study IV), we analysed participants’ compliance with the planned home meals. Analyses were based on the structured questionnaires, showing the proportion eaten of the meals offered. No significant differences were present between protein group and regular group in compliance with study meals. Figure 10 presents the mean frequency (% of the days) that the participants consumed fully the home meal components offered. Approximately 72% of the days in protein group and 65% of the days in regular group, participants ate all protein sources (meat/fish main dish) offered (e.g. no leftovers). Among protein group, most of the days (88%) participants ate the whole snack offered. The participants ate 31% of the days two bread slices and 26% of the days one bread slice of the offered bread slices. Fifteen participants had missing information on bread consumption for some of the days.

![Figure 10](image.png)

*Figure 10. Results show the mean frequency (% of the days) for participants consuming fully the home meal components offered. Every dish was not offered daily, which was taken account in the calculations. Protein source = meat/fish, Side dish = potatoes/rice/pasta, Vegetables= warm vegetables and/or salad.*
7 DISCUSSION

7.1 Main findings

This doctoral dissertation combines two different RCTs conducted in the same area of Pori Social and Health Services. It consists of different groups of older people living at home; caregivers, who were in better physical shape, and home care clients and care recipients, who needed care and support. It describes quite well the variety of aspects that is related to the nutrition of older people.

The studies I and III give important information of the baseline results of the studies, including nutritional status and nutrient intake, that has been reported only little from the community-dwelling older population in Finland. Results showed that the risk of malnutrition and insufficient protein and energy intakes are common among older people living at home, particularly among home care clients. Approximately four out of five elderly people had insufficient protein intake, which highlights the importance of increasing protein intake and finding practical ways to do it. Several factors were associated with the risk of impaired nutritional status and energy and nutrient intakes.

This doctoral dissertation also shows that the protein intake of older community-dwelling people can be increased with different methods. The RCTs had distinct intervention contents: dietary guidance and home-meals – both good ways to support the nutrition of community-dwelling older people. It is important to find the most effective way to support older person individually.

In Study II, tailored dietary guidance including group meetings seemed to encourage older caregivers to increase their protein intake, although no significant differences emerged between the dietary guidance group and the control groups. However, the dietary guidance seemed to be effective among male caregivers, who increased their protein and energy intakes during the six-month intervention.

In Study IV, the protein-rich home meal service, including a snacks and bread, had more benefits on the nutrition and physical performance of older people than regular home meals or control diet. Protein-rich home meal service increased protein intake. It also increased calcium intake and seemed to improve results in the Sit-to-Stand Test. It had no effect on the overall health-related quality of life. Both home-meal services decreased salt intake but also increased saturated fat intake.
7.2 Nutritional status and nutrient intake (Studies I and III)

Nutritional status
As previous studies have reported (Cereda et al. 2016), our results show that the prevalence of malnutrition risk increases as the need for care increases. In Studies I and III, 13–19% of older caregivers, 26% of care recipients and 50% of home care clients had increased risk of malnutrition according to MNA, which is in line with the large meta-analysis and systematic review of Cereda et al. (2016) and other studies (Rullier et al. 2013, Torres et al. 2010). Only few percent suffered from malnutrition, which is typical among community-dwelling older people (Cereda et al. 2016, Rullier et al. 2013, Torres et al. 2014).

In study III, home care clients had the highest prevalence of malnutrition risk, up to half of the participants, as seen in previous studies (Cereda et al. 2016, Kiesswetter et al. 2013, Guigoz 2006). As home care clients may suffer from various diseases and impaired physical function, there may be problems in eating, shopping or preparing foods (Landi et al. 2016), increasing the risk of malnutrition (Volkert et al. 2020, Leij-Halfwerk 2019, Volkert et al. 2019, Favarro-Moreira et al. 2016). Home care clients and care recipients had worse physical and mental characteristics than caregivers, which may have increased their nutritional risk. Also, home care clients were significantly older than caregivers or care recipients, which may also explain the higher prevalence of nutritional problems, since older age has been associated with impaired nutritional status (Leij-Halfwerk 2019). The care recipients had a lower risk of malnutrition than home care clients, likely due to differences in physical condition. For example, care recipients had better scores in the Five Times Sit-To-Stand -test and had less excessive polypharmacy than home care clients. If the care recipients are cared for by non-professional caregivers, such as relatives or other close ones, their physical condition may not be so challenging as among clients of professional home care.

Caregivers had a lower risk of malnutrition than care recipients or home care clients. The result seems logical, as the caregivers in Study III had better cognition and quality of life, they suffered less depression, had lower risk of sarcopenia, better physical performance, and were physically more active than home care clients or care recipients. The prevalence of nutritional risk among caregivers was slightly lower than in previous studies, which report the malnutrition risk to be around 30% (Rullier et al. 2013) or even over 40% (Tombini et al. 2016) among older caregivers. Although the physical performance of caregivers in both of Studies I and III was good, ageing is accompanied by many cognitive, psychological, and social factors that may expose caregivers to impaired nutrition (Corish & Bardon 2019). Caregivers are susceptible to depression and poor mental health, which can affect their
nutritional status (Hiel et al. 2015). In Study I, female caregivers were more likely to be at risk of malnutrition than males, consistent with other studies examining nutrition among older people (Crichton et al. 2019, O’Keeffe et al. 2019). The result is not explained by a lower energy intake among females because the energy intake of females at risk of malnutrition was higher compared to females without the risk. The MNA questionnaire showed that females suffered more psychological stress or acute illnesses than males, but the differences did not reach statistical significance. Nevertheless, these results suggest that gender differences may be explained by psychological factors.

As shown in previous studies (John et al. 2013, van Bokhorst-de van der Schueren 2013), depressive symptoms and medication (O’Keeffe et al. 2019, Fávaro-Moreira 2013) were associated with impaired nutritional status in both Studies I and III. Of all disorders affecting mental health in older people, depression is thought to be the most common cause of involuntary weight loss and malnutrition (John et al. 2013). The use of medication affects either directly or indirectly the risk of malnutrition (Volkert et al. 2020, O’Keeffe et al. 2019, Fávaro-Moreira et al. 2016). Different medications can cause malabsorption or taste alterations or can reduce appetite, leading to decreased energy nutrient intake through many mechanisms (John et al. 2013). Depressive symptoms and medications are both associated with appetite, which was also associated with nutritional status in Study III.

In studies I and III, good quality of life was associated with better nutritional status as in previous studies (Kostka et al. 2014, Rasheed & Woods 2013, Keller 2004a, Keller et al. 2004b). The association is considered to be bidirectional. Poor nutritional status impairs quality of life indirectly as a consequence of increased morbidity and a decline in functional status (de Morais et al. 2013, Lundin et al. 2012, Keller et al. 2004a, Keller et al. 2004b). When nutritional status is improved, it can also lead to significant improvements in quality of life, both physical and mental aspects (Rasheed & Woods 2013).

Better cognition was associated with better nutritional status in Study III. It has been widely established that impaired cognition can result from malnutrition or vice versa. (O’Keeffe et al. 2019, Fávaro-Moreira et al. 2016, Volkert et al. 2015, John et al. 2013). None of the participants in this study suffered from memory diseases because of the inclusion criteria, but the result indicates, that even minor changes in cognition can lead to changes in nutritional status. With declining cognition, various nutritional problems may emerge, leading to reduced dietary intake and malnutrition (Volkert et al. 2015). In the case of even mild dementia, individuals may have problems with shopping, storing, and preparing food (Volkert et al. 2015).
Several physical factors were associated with nutritional status in Study III. As reported in previous studies, hand-grip strength (Bohannon 2019, Norman et al. 2011) and better physical performance measured with SPPB (O’Keeffe et al. 2019) were associated with better nutritional status. Higher risk of sarcopenia was associated with decreased nutritional status, as seen before (Cruz-Jentoft et al. 2017). New findings were that standing and a higher number of daily steps were associated with better nutritional status. Almost half of the participants had low SPPB score and also the approximal physical activity was low, which may explain the results. In addition, over half of the participants were at risk for sarcopenia. As malnutrition plays a key role in the pathogenesis of sarcopenia, it is clear that an association between the two screening methods, MNA and SARC, exists (Cruz-Jentoft et al. 2017). Sufficient energy and nutrient intakes maintain muscle mass and physical functioning (Cruz-Jentoft et al. 2017). When nutrition is impaired, the risk of sarcopenia increases (Cruz-Jentoft et al. 2017).

Compared with Study I, more nutrition-related associations with physical and psychological factors were observed in Study III, which included also older people needing daily care from a caregiver or professional home care. Study I included only informal caregivers in relatively good shape, which probably explain the fact a weaker association with nutritional status was observed. These results strengthen knowledge that various physical and psychological factors are related to nutrition in older people. When the need for care increases, the risk for malnutrition rises.

**Energy intake**

In Studies I and III, the mean energy intakes were below the recommended levels according to the Nordic Nutrition Recommendations, which advice ≥1700 kcal/day for females and ≥2050 kcal/day for males aged 61–74 years (Nordic Council of Ministers 2012). When considering the reference value of >1500 kcal/d proposed by Lowenstein (1982), the mean energy intakes exceeded this, being 1610 kcal/d in Study I and 1546 kcal/d in Study III. Nonetheless, about half of the participants in both studies had energy intake below 1500 kcal/d.

Mean energy intakes of male and female caregivers in Study I were well below the values reported in the systematic review of Ter Borg et al. (2015). In the review, the mean energy intake was 2137 kcal/d among males (n=14 419) and 1737 kcal/d among females (n=19 413), whereas the mean values in Study I were 1798 kcal/d and 1494 respectively. Males had a higher energy intake than females, as males tend to have for many reasons (Xu et al. 2015, Jyväkorpi et al. 2015, Power et al. 2014, Geirsdottir et al. 2013, Tieland et al. 2012).

In Study III, home care clients had significantly less energy than caregivers or care recipients. Home care clients consumed approximately 1364 kcal/d,
which is well below the recommendations (Nordic Council of Ministers 2012) and less than in earlier studies performed with home care clients reporting energy intake to be 1510–1580 kcal/d using 24 h recalls (Johnson & Begum 2008) and 1782 kcal/d using semiquantitative FFQ (Fernández-Barrés et al. 2016).

Energy intake was associated with better nutritional status in both studies, and with better appetite and higher number of warm meals per day in study III. The association between energy intake and nutritional status has been shown before in the study of Guigoz et al. (1997). People with impaired nutritional status usually have lower energy and protein intakes than recommended (Vellas et al. 2006). Since the SNAQ-questionnaire predicts weight loss in community-dwelling older people, it is clear that energy intake is associated with the SNAQ-questionnaire (Wilson 2005). In a previous study, meal patterns have been associated with energy and protein intake in older people receiving home care (Engelheart et al. 2020). One large meal a day had more impact on daily energy and protein intake than did several eating occasions (Engelheart et al. 2020). A proper amount of food at main meals may stimulate energy and protein intake (Engelheart et al. 2020), which may also explain the associations between the number of warm meals and energy intake in Study III.

In both studies, greater hand grip strength was associated with a higher energy intake, consistent with a previous study of community-dwelling older people (Doyev et al. 2021). Furthermore, other physical factors, such as higher number of daily steps, higher moderate-to-vigorous physical activity, and standing were associated with higher energy intake in Study III. These results show that being active may increase energy intake, perhaps via increased appetite and energy needs. Also, total energy intake has been positively associated with skeletal mass, which may explain the associations with grip strength and energy intake (Jang & Bu 2018). Since skeletal muscle is responsible for a substantial portion of the total energy expenditure, supplying sufficient energy intake and nutrients may contribute to conservation of skeletal muscle mass (Jang & Bu 2018) and therefore grip strength.

**Protein intake**

The mean protein intake was below Finnish recommendations in both Studies I and III. The protein recommendation being 1.2–1.4 g/kg BW/d (National Nutrition Council and Finnish Institute for Health and Welfare 2020), the mean intake in Study I was 1.0 g/kg aBW/d and in Study III 0.9 g/kg aBW/d. Four out of five participants in both studies had protein intake under recommendations, showing an important target for improvement. The results are in line with the Finnish study of Koponen et al. (2021), where 79% of older caregivers had inadequate protein intake. Hengeveld et al. (2020) with study
sample of 8107 older community-dwelling people showed that 71% had protein intake under 1.2 /kg aBW/d.

In Study I, female caregivers had significantly greater protein intake, than males when calculated per energy (18.0 E% vs. 16.5 E%). Also, they had greater protein intake when calculated per body weight (1.0 g/kg aBW/d vs. 0.9 g/kg aBW/d), but the results were not statistically significant. Still the total protein intake was lower among females compared to males (66.3 g/d vs. 73.9 g/d). Although all the differences were not significant, these results may indicate different diet quality, since females had lower energy than males. This difference was also shown in the large international systematic review of Ter Borg et al. (2015), where total protein intake was greater among community-dwelling males (n=11 974) than females (n=16 436): 81 g/d vs. 69 g/d. Still, the protein intake per bodyweight was greater in females (1.1 g/kg aBW/d) than in males (1.0 g/kg aBW/d) (Ter Borg et al. 2015). Mendonça et al. (2018) has also showed, that female gender has been associated with higher protein intake. One explanation may be, that male gender has been associated with poorer knowledge of importance of protein intake (Visser et al. 2021). If one does not know where to get protein, it is difficult to obtain sufficient amounts. Also, males are usually heavier, which decreases the protein intake when calculated per body weight. Among male caregivers, a higher alcohol consumption was also associated with lower protein intake, indicating, that alcohol may have replaced some of the foods with good nutritional value in their diets (Satré et al. 2011).

In Study III, no significant differences were found in protein intake between home care clients, caregivers, and care recipients, although home care clients had less energy. However, when looking at the results, a clear trend emerges in total protein intake; home care clients had the least (59 g/d), care recipients slightly more (68.8 g/d) and caregivers the most (71.9 g/d) protein. The same trend can be seen in protein intake calculated per body weight: 0.85, 0.86, and 1.02 g/kg aBW/d respectively. These results may indicate, that when daily energy intake is lower there are challenges in ensuring adequate intake of protein from a regular diet (Ter Borg et al. 2015). The results are also in line with previous studies showing that when the need for care increases, the protein intake decreases (Tieland et al. 2012).

Physical factors, such as greater hand grip strength, higher amounts of daily steps, moderate-to-vigorous physical activity, and standing were associated with greater protein intake in Study III. Also, higher risk of sarcopenia was associated with lower intake of protein. As growing evidence shows, sufficient protein intake benefits muscle mass, strength, and functioning among older people (Reinders et al. 2022, Deutz et al. 2014, Bauer et al. 2013, Wolfe 2012). An imbalance between protein intake and protein needs can result in loss of skeletal muscle mass because of a chronic disruption in the balance between
muscle protein synthesis and degradation (Cruz-Jentoft et al. 2017). Older individuals need strength and physical performance to cope with everyday chores and taking care of the household. When physical functioning decreases, it increases the risk for malnutrition in many ways, including causing problems in eating, getting foods, or preparing foods (Landi et al. 2016). It can also lead to reduced appetite and altered food and nutrient intake (Landi et al. 2016).

In Study III, better nutritional status, better appetite, and greater number of warm meals per day were associated with higher protein intake. Also, in the study of Jyväskylä et al. (2016), the MNA scores were positively associated with nutrient intakes. Still, it is important to note, that in the previously mentioned study MNA failed to recognize older people with low energy and protein intakes (Jyväskylä et al. 2016). This means that also people with normal nutritional status may have inadequate nutrient intakes and may thus be at risk of malnutrition (Jyväskylä et al. 2016). Poor appetite has been associated with insufficient protein intake in a large international meta-analysis (Hengeveld et al. 2020). This association is probably related to the phenomenon known as the anorexia of ageing, an accelerated loss of appetite with advancing age that increases the risk of reduced food intake (Hengeveld et al. 2020). In the study of Engelheart et al. (2020), the authors showed that one large meal a day had more impact on daily protein intake than did several eating occasions. This highlights the importance of proper meals in the diets of older people and may explain the association between number of warm meals and protein intake in Study III.

These above-mentioned findings confirm that the majority of community-dwelling older people have protein intake under recommended levels. As the need for care increases, the protein intake appears to decrease. There were also several factors related to protein intake, most of them physical. These results highlight the need for systematic nutritional assessment among older people living at home.

Other nutrients
In both Studies I and III, the mean intakes of dietary fibre and folate were under recommended levels as in previous studies (Koponen et al. 2021, Silva et al. 2019, Jyväskylä et al. 2015). Insufficient intake of fibre was more common among home care clients, who also had less energy in their diets. When energy intake is low, it also decreases the intake of other nutrients (Ter Borg et al. 2015). Moreover, intake of fibre has previously been inversely associated with polypharmacy (Heuberger & Caudell 2011), which may explain the result, since home care clients in our study used more medication than other groups. In Study III, also the mean intakes of potassium, iron, and vitamin E were lower than recommended, earlier research has also shown
The intake of vitamin D was below the recommended levels in both studies, especially among participants aged ≥75 years in Study III. The vitamin D recommendation is higher for people aged ≥75 years than for younger people (National Nutrition Council and Finnish Institute for Health and Welfare 2020) so the proper amount of vitamin D from the diet is even harder to attain in the oldest individuals. However, in Study I, caregivers’ mean plasma 25-OH-vitamin D levels were good, being 80.8 nmol/l, when the minimally sufficient value is considered to be 50–75 nmol/l (Carlberg & Haq 2018). Levels were good, even though the laboratory tests were taken during the dark season of the year (from October to January). Almost four out of five caregivers took a vitamin D supplement, and the use was significantly associated with vitamin D status. This highlights the importance of vitamin D supplementation among older people. It also reflects how well vitamin D supplementation recommendations have been implemented in Finland.

In Study III, intake of saturated fatty acids was higher than recommended for almost all participants (94%). Studies of older people in Europe have reported unfavourable intakes in fat, such as total fat, and saturated fat, among older community-dwelling people (Kehoe et al. 2019, Valsta et al. 2018, Jyväkorpi et al. 2015, Ter Borg et al. 2015). Intake of saturated fatty acids has recently been associated with lower extremity functional impairment in older adults and the quality of fat has been associated with risk of sarcopenia and frailty (Arias-Fernández et al. 2020, Jyväkorpi et al. 2020, Struijk et al. 2020), thus it is important to pay attention to the quality of fats among older people.

While low micronutrient intakes among older people are usually explained by the relatively low energy intake, the quality of the diet is another important factor. In the study of de Groot et al. (1999), the authors noted, that even very high intakes of energy did not guarantee adequate nutrient intakes among older people. Of all people with energy intake of 1900 kcal/d or more, 13% of males and 16% of females did not have adequate nutrient intake (de Groot et al. 1999). This highlights the importance of variety and good food quality in the diets of older people.

### 7.3 Dietary guidance (Study II)

In the Care Nutrition trial (Study II), tailored dietary guidance including group meetings seemed to encourage older caregivers to increase their protein intake, although no significant differences emerged between the intervention and control groups, except for male caregivers. The protein intake increased statistically within the guidance group, where the protein intake increased
from 0.86 to 0.96 g/kg aBW/d. Even without a significant results, these findings can some extent be considered similar to those of previous studies. Previously, nutrient intake has been improved by interventions with tailored dietary guidance with group meetings (Fernández-Barrés et al. 2017, Rousset et al. 2006) and with cooking classes (Jyväkorpi et al. 2014). In the RCT study of Rousset et al. (2006), a two-week intervention with one group meeting and personal feedback on the diet increased protein intake by 0.041 g/lb/d (0.09 g/kg/d) among community-dwelling older people in France. The result is similar to the changes seen within the guidance group here. The protein intake in guidance group increased to almost 1.0 g/kg aBW/d, which has several benefits, even though we did not reach the intervention target of ≥1.2 g/kg aBW/d. The protein intake of 1.0 g/kg/d can help improve muscle mass, strength, and functional ability and protects against weight loss (Nowson & O’Connell 2015, Deutz et al. 2014, Bauer et al. 2013), which is important among caregivers taking care of another persons.

The dietary guidance was significantly effective among male caregivers who increased their protein and energy intakes during the six-month intervention. Among male guidance group, protein intake increased from 0.89 to 1.0 g/kg aBW/d, and among male control group decreased from 0.79 to 0.72 g/kg aBW/d. There may be several factors that could explain why male benefitted more from dietary guidance. Only half of these male caregivers prepared their family meals, and therefore may need more guidance to improve their initiative. Taking on a caregiver’s role changes the situation at home if the person is unfamiliar with household care. Preparing food and grocery shopping have traditionally been women’s work among older people of this generation in Finland (Roos et al. 2001). Older males may have poor cooking skills and inadequate nutritional knowledge (Hughes et al. 2004, Roos et al. 2001), especially when it comes to protein knowledge (Visser et al. 2021). These have been associated with a poor-quality diet among older people (Hughes et al. 2004, Baker & Wardle 2003). Male gender is also known to be associated with poor nutrient intake and increased concerns about nutrition among caregivers (Puranen et al. 2014, Fjellström et al. 2010). According to the feedback in our study, male caregivers were more satisfied with the dietary guidance than females, even though the results between genders was not significant. Our results support the findings implying that older male caregivers need special support to cope with household activities, and that combining dietary guidance with practical learning, such as cooking courses, may be an effective teaching method. It has been suggested that community-based nutrition and cooking guidance may be beneficial educational activities among older male (Keller et a. 2004c).

The intervention in the Care Nutrition trial had several positive elements, that may have affected dietary changes particularly in protein intake. According to four systematic reviews (Rea et al. 2019, Marshall et al. 2013, Bandayrel &
nutritional education can positively influence nutrition-related outcomes. Active participation and collaboration, as in the Care Nutrition trial, have shown the most promise in affecting nutrition-related outcomes (Bandayrel & Wong 2011). From the author’s point of view, especially participation in cooking classes seemed to inspire caregivers to find new recipes and ways to cook. The joint pleasure in cooking was evident, and participants enjoyed eating together. Dietary guidance, both tailored personal guidance and group guidance, had elements of motivational guidance. The nutritionist and the caregiver discussed appropriate nutritional aims together, which probably improved the motivation to make changes. The main aims were usually related to finding easy and practical ways of increasing protein intake. As known, food- and meal-based strategies, rather than supplemental drinks, are recommended as the initial approach to optimizing protein intake (Nowson & O’Connell 2015). Nutrition interventions should be individualized and contain practical advice, as in the Care Nutrition trial (Jyväkorpi et al. 2021). Also, interventions need to be achievable and acceptable to older people in the long-term, in order to incorporate them into a dietary pattern that meets their dietary requirements (Nowson & O’Connell 2015). Discussing the possible changes with participants probably also increased the acceptance of the intervention. Participants had a written nutritional care plan, which was completed during the guidance. Written feedback and educational materials of the main aspects of the guidance sessions have been reported to be among the most important factors in nutritional interventions (Jyväkorpi et al. 2021).

There may be several reasons, why the intervention did not show significant improvements between guidance group and control group. We were unable to recruit sufficient number of participants, which weakens the statistical power of the sample. With sample-size calculations for 102 participants, only 69 caregivers completed the Care Nutrition trial, 55 of whom had protein intake under recommendation at baseline. The sample in Study II is therefore too small according to sample-size calculations. Selection bias is possible because the participants were in rather good physical shape and were keen to be involved. This may indicate that they were more health conscious than the average older population, potentially affecting the effectiveness of the intervention. The intervention period of six months could have contained more dietary guidance than it did since one dietary guidance session may be insufficient to make permanent changes over that time period. Also, every fourth participant did not participate in group guidance. Of those who did participate, two out of three considered the group meetings to be useful. Since protein intake also increased slightly in control group, albeit not significantly, this may have affected the results that no statistical differences were found between guidance group and control group. At the beginning of the trial control group also received written nutritional material that highlighted the importance of proper protein intake. Control group contamination could also explain the increase in protein intake, since the trial was conducted in a small
city and the participants may have known each other from the caregivers’ peer-support groups and events. Adequate protein intake was highlighted in the guidance and this message may have spread.

The “Sarcopenia and Physical Frailty in Older People: Multicomponent Treatment Strategies” (SPRINTT) project conducted a multi-centre RCT with the objective of determining the effect of physical activity and nutrition intervention on prevention of mobility disability in community-dwelling frail older Europeans (Jyväskylä et al. 2021). The authors reported that the reasons for non-adherence to the intervention included a lack of interest or considering nutrition guidance useless, not liking the guidelines, depression, lack of willpower, old habits, cognitive issues, or problems with hearing or eyesight (Jyväskylä et al. 2021). Since the feedback from the Care Nutrition intervention consisted of less information, we can only speculate whether some of the reasons mentioned above also affected in the Care Nutrition trial. From the author’s point of view, feedback from the intervention seemed to be positive, but caregivers may have had troubles focusing on their own diet and may have lacked the willpower to make changes. Caregivers are known as the "invisible patients", who usually stay in the background and focus on the health of the care recipient (Adelman et al., 2014). This may have affected the results for caregivers.

7.4 Home-delivered meals (Study IV)

The Power Meals trial (Study IV), showed that the eight-week protein-rich home meal service (protein group) increased protein, calcium, and saturated fat intakes and lowered salt intake among older people living at home. The service also seemed to improve lower limb strength measured with the Sit-to-Stand Test but had no other effects on the total SPPB score or quality of life. The regular home meal service (regular group) decreased salt intake and increased saturated fat intake, but had no effects on protein intake or other nutrients, physical performance, or quality of life.

Nutrient intake
Protein-rich meals, snacks, and bread (protein group) increased participants’ protein intake from 0.92 to 1.03 g/kg aBW/d, meaning + 0.11 g/kg aBW/d increase in the protein intake calculated per bodyweight. The result is line with previous studies showing that home-delivered meals can increase protein and other nutrient intakes (Walton et al. 2020, Shan et al. 2019, Leedo et al. 2017, An 2015, Zhu & Ann 2013). The mean increase in the total protein intake was 9.4 g/d, consistent with results reported earlier in home meal interventions. Home meal service has been found to be associated with a net increase in the daily intake of protein of 8.4 g among non-institutionalized older adults in USA using a home-delivered meal programme (An 2015) and 7.4 g/d among
frail older people using (new users) Meals-on-Wheels service in Canada (Roy & Payette 2006). The favourable effects of protein-rich meals in home meal services have been seen before also in the study of Ziyalan et al. (2017) and Borkent et al. (2019), where protein-rich ready-made meals were found to be effective in protecting older adults from a decreasing protein intake after switching from self-prepared meals to ready-made meals. In Study IV, we used only regular foods, and not clinical products or supplements, which may have increased the acceptability. The food service provider designed the menus emphasizing older people’s typical nutritional habits, variability, possible chewing problems and general diets, such as lactose intolerance or celiac disease, which also helped to adopt the home-delivered meal service.

Protein-rich snacks were probably the most effective intervention element in increasing the protein intake in protein group, because most of the excess protein came from protein-rich snacks. Well-timed and nutritionally appropriate snacks in addition to meals can improve the diet and nutrient intake among older people (Engelheart et al. 2019, Marangoni et al. 2019). The provision of an extra daily snack may be a useful addition to existing home meal services to improve nutrient intakes and diet quality (Fleury et al. 2021, IJMker-Hemink et al. 2020, Volkert et al. 2019, Charlton et al. 2013). In the systematic review of Fleury et al. (2021), the authors concluded that the effect of home-delivered meal services on nutritional status and nutrient intake is even higher when the home-delivered meal service is enhanced by adding supplementary snacks/meals or enriched food (Fleury et al. 2021). The mean amount of protein in snacks was 16.0 g, which is twice the amount of protein that older people consumed at snack time in previous studies (Krok-Schoen et al. 2019, Hengeveld et al. 2019). Charlton et al. (2013) evaluated the feasibility of providing a high protein snack in addition to a home meal and found a 7.2 g/d increase in protein intake, which is in line with our results. Having ready-prepared snacks available may be a good reminder to participants to eat between meals (Charlton et al. 2013, Roy & Payette 2006, Moran 2004). We used mainly milk-based products, which have been demonstrated to be effective in increasing protein intake (Houchins et al. 2017). It also may have affected the increase of calcium intake in protein group, which is an important nutrient in old age, especially for bone health. Denissen et al. (2017) and Frongillo & Wolfe (2010) hav also reported a significant increase in calcium intake while using home-delivered meals.

Even though participants in the protein group increased their protein intake, most did not attain the intervention target of ≥1.2 g/kg aBW/d protein intake recommended in Finland for older people (National Nutrition Council and Finnish Institute for Health and Welfare 2020). The recommended intake was probably hard to reach, because the protein intake at baseline was low, only 0.92 g/kg aBW/d in protein group and 0.93 g/kg a BW/d in regular group. Additionally, the study meals were not always completely consumed, as almost
one-third of participants in protein group did not eat the protein component fully, and only one-third of participants ate two bread slices, which was the recommendation in the intervention. At the end of the study, more participants receiving either protein-rich home-delivered meal service or regular home-delivered meal service reached the 1.2 g/kg aBW/d target than in control group: protein group 27%, regular group 13%, control group 5%. However, the results were not statistically significant. The result among protein group is similar to the findings of Hengeveld et al. (2020), where 29% of community-dwelling people aged ≥55 years had protein intake under 1.2 g/kg aBW/d. The protein intake among protein group increased to 1.03 g/kg aBW/d, which has several positive effects, including preservation of lean body mass, physical functions, and health (Volkert et al. 2019, Houston et al. 2017). Some experts recommend a protein intake of 1.0–1.2 g/kg/d (Deutz et al. 2014, Bauer et al. 2013). Since we chose the higher cut-off value of 1.2 g/kg/d based on Finnish recommendations, this affects our results markedly.

The energy intake did not decrease in protein group, meaning that the protein intake could be increased without impacting the overall energy intake, even though protein is known to be the most satiating macronutrient (Clegg & Williams 2018) and thus may reduce eating and affect energy intake. It seems that the participants maintained their relative caloric balance, even with more calories provided in the protein group by snacks and bread. However, the participants did not always eat the whole amount of the meals and snacks provided, which affects the reliability of the results.

The interventions showed a great decrease, approximately 2.5 g/d, in salt intake among the participants receiving home meals in both intervention groups. Similar results have not been reported before. This reduction may be explained by the fact that most salt intake comes from bread (Quilez & Salas-Salvado 2012). When snacks consisting of bread are replaced with a proper lunch and protein-rich snacks, the consumption of bread may decrease. Also, the salt content of the home-delivered meals may have been lower compared to the meals participants prepared themselves. However, we did not measure the amount of salt participants may have added themselves, which limits the reliability of the results. The home meals also had some negative effects on participants’ diets, with an increase in saturated fat intake among protein group and regular group. The home meals and desserts were prepared using creams and other fat-rich products to improve flavour. Optimizing the flavor of home meals is considered to have an impact on protein intake (IJmker-Hemink et al. 2020). On most (89%) of the intervention days, dessert was consumed fully, which probably increased the saturated fat intake in the intervention groups. In the future, better focus on the fat quality would be useful for improving the fatty acid composition of the products offered.
Physical performance

The protein-rich home meal service (protein group) seemed to improve the participants’ results in the Sit-to-Stand Test compared with the other groups. This finding is in accord with an earlier study in which improvement in lower body strength was detected after a 12-week energy- and protein-rich home meal service (Leedo et al. 2017). Also, Tieland et al. (2012) were able to improve the Sit-to-Stand Test time among frail older people after a 24-week intervention with protein-rich beverages, adding a total of 30 g protein daily.

According to the baseline results in the Sit-To-Stand Test, most participants (68%) had worse performance than the average reference group aged 70–79 years. Also, 45% of all participants had poor physical performance according to SPPB total score. These results may indicate, that this group of older people benefitted from the protein-rich home-delivered meal intervention, since the overall physical performance had challenges. Results were seen in only eight weeks, which can be considered a short time relative to other studies. The study meals in protein group contained approximately 25.5 g protein/meal; this is deemed an optimal portion of protein to conserve muscle mass (Nowson & O’Connell 2015). Several studies have shown, that 25–30 g of a high-quality protein/meal is necessary to reach the threshold for maximal stimulation of muscle protein synthesis in older adults (Paddon-Jones et al. 2015, Deutz & Wolfe 2013). Since protein-rich snacks and bread were offered in protein group, the protein intake may have been distributed better during the day in protein group than in regular group. In addition, the snacks were most often dairy-based products, which are associated with better physical performance in older women (Radavelli-Bagatini et al. 2013).

There were no differences between groups in physical performance according to SPPB total score or hand-grip strength, as seen in previous home meal interventions (Beelen et al. 2017, Denissen et al 2017). There may be several reasons, why the intervention did not show improvements. The final sample size was small in all groups, which limits the statistical power. An intervention period of eight weeks may be too short to show significant results in physical performance measured with SPPB, even though studies have seen some improvements in physical performance outcomes within the first six weeks of a nutritional intervention (Beelen et al. 2017). Our interventions lacked exercise, which is known to be an important factor in improving physical performance when combined with sufficient protein intake (Deutz et al. 2014, Bauer et al. 2013, Tieland et al. 2012). Also, most participants’ protein intake was under recommended levels, which can negatively affect the changes in physical performance.
Quality of life
Both home meal services had no impact on participants’ quality of life, according to the 15D total score. There are only a few earlier studies reporting the effects of home-delivered meals on older community-dwelling people’s quality of life. Gleason et al. (2002) showed an improvement in the quality of life with home-delivered meals and snacks accompanied by weekly telephone diet education. The result may be explained by the people receiving home-delivered meals having fewer worries and concerns about making good food choices, which may reduce anxiety and improve mood (Gleason et al. 2002). Similar to the results in Study IV, Denissen et al. (2017) investigated functionally disabled community-dwelling older people who received a three-month daily meal service consisting of dinner and snacks but found no effects on quality of life. In Study IV, the intervention improved two dimensions of quality of life among protein group: excretion, referring to bowel habits and urination, and daily activities. The improvement in daily activities may be explained by participants’ lower limb strength being improved in protein group. Bowel problems in older people have a considerable impact on the quality of life (Spinzi 2007). As many older people living alone skip meals or do not eat any main meals, home meal services have the potential to make mealtimes more consistent (Timonen & O'Dwyer 2010), which may also positively affect bowel habits.

7.5 Comparison of effectiveness results (Studies II and IV)
Both interventions in the Care Nutrition trial (Study II) and the Power Meals-trial (Study IV) seemed to increase protein intake, even though the result in Study II was significant only among male caregivers (guidance group) and in Study IV among protein group, who received protein-rich meals, snacks, and bread. Surprisingly, dietary guidance and home-delivered meals showed both a mean increase of 0.11 g/kg aBW/d, despite the interventions being very different.

The Care Nutrition trial included tailored dietary guidance and group meetings requiring active motivation and participation from participants in order to be effective. In the Power Meals trial, the intervention was somewhat easier on the participant since ready meals were offered and no other changes were required in the diet. When thinking about how these interventions can be implemented in real life, it all depends on the target group and their possibilities to participate and to make changes in their diets and eating routines. Caregivers were a good target group for dietary guidance since they the ability to make dietary changes. Home care clients and care recipients were
important target groups for home meals since they often have problems in their daily activities, such as preparation of meals. Older caregivers are under a great burden so daily home meals probably made everyday life much easier for them as well. In the future, it is important to assess the needs and possibilities to make changes among the target group or individual in order to decide which intervention is most suitable.

In both intervention studies, the mean increase of 0.11 g/kg aBW/d protein is a good addition to the existing intake, since in both studies the protein intake increased to 1.0 g/kg aBW/d (Study II, male guidance group) and to 1.03 g/kg aBW/d (Study IV, protein group). This increase has several positive effects on health and physical performance, as already discussed. The mean increase of 0.11 g/kg aBW/d in protein intake means about 7.7 g total increase among persons weighing 70 kg, which could be compared to one snack for example. Even though the clinical effect may seem marginal, every increase towards the recommendations is an advantage. Also, it is important to find ways to prevent at possible decrease in protein intake.

It can be speculated, whether greater improvement in protein intake would require protein enrichments and supplements in addition to regular food in these kinds of interventions. We wanted to keep both interventions as practical and realistic as possible since practical interventions have been shown to improve diet and food intake (Clegg & Williams 2018). We also wanted to conduct interventions that can be implemented in real life, either in municipal health care or by home meal providers. A goal would be to gain more information on the effectiveness of dietary guidance and home-delivered meals with high-quality randomized controlled trials.

7.6 Strenghts and weaknesses of methods (Studies I-IV)

Recruitment and participants
In both trials, recruitment was performed with the assistance of health care professionals. Because of the specificity of our recruitment and the strict inclusion criteria in both RCTs, the numbers of participants were insufficient based on power calculations and the study population may have been selected. In other similar studies, however, the sample size has been about the same (Jyväkorpi et al. 2014, Rydwik et al. 2008, Rousset et al. 2006). Even though the study groups were small, they represent the older population of people living at home quite well. The population of older people is heterogenic, and there are people who have problems with their physical performance and need municipal help (e.g. home care clients) and others who are in very good shape helping for their spouses or relatives (e.g. caregivers).
The recruitment had several challenges. We experienced a lack of time in the recruiting; the recruitment period would have needed to be longer to achieve the targeted sample sizes. In the Care Nutrition trial (Studies I and II), many caregivers did not have the energy or the interest to participate. In the Power Meals trial (Studies III and IV), the recruitment was done in the summer in hot weather, which may have affected participants’ motivation to become involved in anything new that would have required extra effort. Also, home care clients and care recipients may have had some medical and physical issues, that prevented participation. The final sample sizes were therefore smaller than expected, impacting the statistical power, and thus affecting the results. Also, selection bias is possible because the participants were first selected from all caregivers, home care clients and care recipients in Pori Social and Health Services according to inclusion criteria. Also, the participants who wanted to participate may have been more health conscious than the average elderly population.

Both trials included older caregivers, who have other nutritional risk factors than home care clients or care recipients. They may suffer from the so-called “caregiver burden”, which may result from providing care for a patient with a chronic illness; the caregiver often takes on many duties, such as assisting with daily activities, managing medication and treatment regimens, scheduling and accompanying the chronically ill patient to medical visits and making treatment decisions (Adelman et al. 2014). Caregivers are also considered to be “invisible patients”, as they are often forgotten by physicians who fail to ask about the caregiver’s mental and physical well-being throughout the disease course of the care recipient (Adelman et al., 2014). In both trials, the caregivers had good cognition measured with MMSE and good physical functioning according to their ADL and IADL tests and physical measurements such as SPPB and accelerometer. Only one in ten suffered from mild or moderate depression. Overall the participants were in good physical shape and keen to participate, which may indicate selection bias, as is typical in intervention studies.

The Power Meals trial (Studies III and IV) included also people in need of care, and those who had different medical and physical risk factors related to nutrition. Overall, we wanted to reach a variety of older people living at home with different kinds of challenges in their lives. This gave us a good opportunity to compare different groups with different care needs. Participants, especially home care clients and care recipients, had many risk factors, such as risk of sarcopenia, poor physical performance, and depression symptoms, thus forming a group likely to benefit from home meal services (Volkert et al. 2019, Zhu & Ann 2013). Home care clients and care recipients differed from the sample of caregivers, since caregivers were in better physical and mental shape than the other groups. This brings a valuable aspect to the study results.
Setting
This doctoral dissertation consisted of two randomized controlled trials, which is the type of study setting that is considered the most strict way of determining whether a cause-effect relation exists between the intervention and the outcome (Kendall 2003). In Study II, we assessed the effectiveness of tailored dietary guidance on nutrient intake among older caregivers, males especially, with protein intake under recommendations. With this setting, we were able to highlight the importance and need for preventive dietary guidance among older caregivers. In Study IV, we explored the effectiveness of protein-rich home meals and regular home meals among older people who lived at home and had many nutritional risk factors. The study consisted of three arms, two interventional and one control, which is an excellent setting of comparing the effectiveness of two different home-delivered meal services. No other study has been conducted before with an intervention that includes protein-rich home meals, snacks, and bread, without using artificial protein enrichments. The findings from both trials could be used in planning nutritional intervention for different groups of older people.

Both trials were conducted in the area of the Pori Social and Health Services by the same nutritionist (author), geriatrician and for the most part with the same research team. Neither the participants nor the researchers could be blinded due the characteristics of the interventions, which can be considered a limitation. However, the study nurses and the nutritionist were trained to follow the study protocol. The author participated in all phases of the studies, including study design, recruitment, data collection, nutrition interventions, and results analysis and reporting, which means that the author is thoroughly familiar with both studies.

The intervention durations had potential limitations in both trials. The intervention time of six-months in the Care Nutrition trial was probably too long in relation to the content of the intervention. Tailored dietary guidance was given only once, which was probably too little. In other studies, six-month intervention have included more than one dietary guidance (Pöllönen et al. 2017, Schilp et al. 2013). Since our target was to perform intervention, that could be implemented in real life at the heath care services, the intervention had to be realistic in relation to resources. Also, the group meetings added valuable content to the intervention.

On the contrary, the intervention time in Power Meals trial would be considered too short, since the eight-week time may not be long enough to show improvements in the physical performance, as seen in the results of the total SPPB score. In nutrient intake, the intervention time can be considered to be enough, since even with shorter interventions there has been improvement in nutrient intakes with home-delivered meals (Borkent et al.
2019). Also, adding instructions to increase physical activity may have had improved the results, since physical activity in addition to sufficient protein intake have shown promising results in improving physical performance. In the future studies, home-delivered meals combined with physical activity intervention may show greater benefits on physical performance.

**Measurements**

Both RCTs used similar methods, which increases the comparability of the results. Baseline measurements were carried out prior to randomization and with the same researchers to minimize bias. Study nurses were trained to do the baseline and final measurements, which increases the reliability of the results. The study nutritionist performed also the baseline and the measurements in addition to dietary guidance, which can be considered as a weakness due possible bias.

To assess nutrient intakes, three-day food records were used, which are considered a good method for evaluating dietary intake among older people in community settings (Engelheart & Akner 2015, Gariballa & Forster 2008, Thompson & Byers 1994). Participants were instructed to include one day from the weekend to give reliable information on their habitual nutrient intake, since food consumption usually differs between weekdays and weekends (Straßburg et al. 2019). However, nutrient intake assessment with food records, can be challenging, as they may be affected by considerable intentional or unintentional under- or overreporting of the foods consumed (Bailey 2021, Naska et al. 2017). To improve the accuracy, we performed check calls to confirm the amounts and types of foods consumed. The three-day time-period may be too short to show the actual food intake over a longer period, but it still the mostly commonly used time period since participant burden can cause a decline in the quality of information recorded if more days are recorded (Bailey 2021). The Finnish National Food Composition Database was used to analyse food intake, which may have affected the results since the database does not include all of the foods that the participants consumed. Some compromises therefore had to be made in the analysis of the food records.

In the Power Meals trial (Study IV), we did not precisely measure how much of the intervention meals were eaten by the participants, which could have biased the study results. Participants completed a daily structured questionnaire reporting the average amount of meal components consumed of the delivered portions, but the questionnaire does not reveal the actual portions consumed. However, participants were obedient, and filled the questionnaires carefully, which increases the reliability of the results.

To assess nutritional status, we used the MNA instrument, which has been widely used validated for older people (Vellas et al. 2006, Vellas et al. 1999).
Despite that, its sensitivity and specificity to identify those with poor energy and protein intakes has been poor (Jyväskorpi et al. 2016). Therefore, the MNA may not have identified those people who were at an early stage of developing malnutrition. We used a global measure, the SPPB, to assess physical outcomes in Study IV. According to Freibergerin et al. (2012), the SPPB can be recommended most highly in terms of validity, reliability and responsiveness to measure the change in physical function among older people. In both trials, we also used some rare measurements, such as plasma 25(OH)D vitamin levels and accelerometer to examine less frequently investigated factors associated with nutritional status and nutrient intake. Also, all participants underwent a thorough geriatric evaluation before being included in the studies.
8 CONCLUSIONS

1. Malnutrition risk and insufficient protein and energy intakes were common among older people living at home, especially in home care clients. Four out of five participants had insufficient protein intake, which highlights the importance of increasing protein intake and finding practical ways to do this. Several factors were associated with the risk of impaired nutritional status and nutrient intakes (Figure 11).

2. Tailored dietary guidance including group meetings seemed to encourage older caregivers to increase their protein intake, even though no significant differences emerged between the intervention and control groups. The dietary guidance seemed to be statistically effective among male caregivers, who increased their protein and energy intake during the six-month intervention (Figure 12). Tailored dietary guidance with group meetings appears to be a good way to increase protein intake in the elderly and should be considered a viable alternative to nutritional interventions.

3. Protein-rich home meal service including snack and bread had more benefits on the nutrition and physical performance of older people than regular home meals (Figure 12). Protein-rich home-delivered meal service increased protein intake compared with other groups. It also increased calcium intake, and improved results in the Sit-to-Stand Test compared with the control group but had no effect on the overall quality of life. Both home-meal services decreased salt intake and increased saturated fat intake relative to the control group. Home-delivered meal services with a special focus on protein content and snacks can be considered a good way to improve nutrition among older people.
Figure 11. Associations of nutritional status, protein intake and different factors

Figure 12. Effectiveness of nutritional guidance and home-delivered meals on nutrient intake and physical performance. The results for nutritional guidance are presented for male caregivers, who had statistically significant results.
9 IMPLICATIONS FOR CLINICAL PRACTICE AND FUTURE STUDIES

1. Assessment of nutrition
The nutritional status should be assessed regularly to ensure optimal prevention and nutritional care among community-dwelling older people. Individuals in need of care may have more risk factors for malnutrition and functional impairment, and thus their nutritional requirements and needs for proper nutritional care should be recognized. Also, recognition of possible nutritional problems of older caregivers is important, since they may often remain in the background as “invisible patients”.

2. Attention to protein intake
Food and nutrient intake should be assessed regularly to ensure optimal nutrition and to enable support actions and guidance. Most community-dwelling older people may have challenges in protein intake, highlighting the need for proper protein screeners and ways to increase protein intake. More low-threshold interventions are needed to identify practical ways to increase protein intake.

3. Offering dietary guidance
Dietary guidance should be integrated as a part of normal care among older people. Health-care experts should guide older people and promote healthy diets, particularly adequate energy, and protein intake. Optimally, the guidance should include personal and group guidance to motivate and activate the participants. Involvement of caregivers as part of the nutritional care for community-dwelling older people is important, and special attention should be given to male caregivers, who may need extra support.

4. Education of professionals
Although awareness of nutritional problems and ways to support good nutrition has increased, there is still a need for nutrition education among healthcare workers and all sectors working with older people. Health care workers should be educated to support the nutrition of all people living in the home, i.e. both healthy individuals and people in need of care. The differences and special needs of people with different conditions must be recognized and supported properly. The nutrition recommendations and dietary guidelines for older people should be implemented in all health care sectors.
5. **Modifying home-delivered meal programmes**

   Home-delivered meals should be offered to all people in need. It is an easy and practical support service to improve diet and nutrient intake. Home-delivered meal services should be modified to meet the needs of older people, particularly in terms of sufficient protein intake. This can be achieved by increasing the protein contents of the products offered. Also, traditional home meal services should be expanded to cover more of the daily meals and snacks, if necessary. Additional services, like offering bread and other meal components should be considered.

6. **Future studies**

   More studies are required to obtain detailed information on nutritional status and nutrient intake among older community-dwelling people. There is need for randomized controlled, high-quality trials to determine the most effective and feasible methods for improving nutritional status and nutrient intakes among older people. Special groups in need of nutritional care and guidance should be recognized and included in the studies. Research should include especially people at risk of malnutrition or with insufficient nutrient intake, to gain valuable information about intervention effectiveness among those in special need. Home-delivered meals are an important supportive service in the older population, and more studies are required to determine the effectiveness of different home meal programmes, especially those with wider content than regular home meals.
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