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NUTRITION OF OLDER PEOPLE AND THE EFFECT OF NUTRITIONAL INTERVENTIONS ON NUTRIENT INTAKE, DIET QUALITY AND QUALITY OF LIFE

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ACADEMIC DISSERTATION

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LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following original articles (I—III, V) and the study protocol for a randomized controlled trial (IV) referred to in the text by Roman numerals I—V.

I Jyväkorpi SK, Pitkälä KH, Puranen TM, Björkman MP, Kautiainen H, Strandberg TE, Soini H, Suominen MH. Low protein and micronutrient intakes in heterogeneous older population samples. Arch Gerontol Geriatr 2015;15:30022—30024.

II Jyväkorpi SK, Pitkälä KH, Puranen TM, Björkman MP, Kautiainen H, Strandberg TE, Soini H, Suominen MH. High proportions of older people with normal nutritional status have poor protein intakes and low diet-quality (submitted).

III Jyväkorpi SK, Pitkälä KH, Kautiainen H, Puranen TM, Laakkonen ML, Suominen MH. Nutrition education and cooking classes improve diet quality, nutrient intake, and psychological well-being of home-dwelling older people- a pilot study. J Aging Res Clin Practice 2014;3:120—124.

IV Jyväkorpi SK, Puranen T, Pitkälä K, Suominen MH. Nutritional treatment of aged individuals with Alzheimer disease living at home with their spouses: study protocol for a randomized controlled trial. Trials 2012;24;13:66.

V Suominen MH, Puranen T, Jyväkorpi SK, Eloniemi-Sulkava U, Kautiainen H, Pitkälä KH. Nutritional guidance improves nutrient intake and quality of life, and may prevent falls in aged persons with Alzheimer disease living with a spouse (NuAD trial). J Nutr Health Aging 2015;19:901—907.

LIST OF ABBREVIATIONS

AD = Alzheimer's disease
ADL = activities of daily living
AI = adequate intake
ALF = residents of Helsinki assisted living facilities
AR = average requirement
AUC = area under the curve
BEE = basic energy expenditure
BMI = body mass index
BW = body weight
CCI = Charlson comorbidity index
CDR = Clinical Dementia Rating
CG = caregivers
CW = community-dwelling
DRI = dietary reference intake
EFSA = European Food Safety Authority
EWGSOP = European Working Group on Sarcopenia in Older People
FFQ = food frequency questionnaire
FNR = Finnish Nutrition Recommendations
GERD = Gastroesophageal reflux disease
GI = gastro-intestinal track
g/kg BW=grams per kilogram of Body Weight
15D HRQoL = 15D- Health related quality of life
HBS = Helsinki Businessmen Study
IADL = Instrumental activities of daily living
IDQ = Index of diet quality
IRR = incidence rate ratios
LI = lower intake level
LR = likely hood ratio
LTC = long-term care
MedDiet = Mediterranean diet
MMSE = Mini Mental State Examination
MNA = Mini Nutritional Assessment
MNA-SF = Mini Nutritional Assessment Short-form
MUFA= monounsaturated fatty acid
NNC = National Nutrition Council
N-balance = Nitrogen balance
NC = nutrition education and cooking class
NGO = Non-governmental organization
NH = Nursing home
NuAD = Nutrition and Alzheimer-study
ONS = oral nutritional supplements
PAL = physical activity level
PEM = protein-energy-malnutrition
PSNT = Porvoo Sarcopenia and Nutrition Trial
PUFA = polyunsaturated fatty acid
PWB = psychological well-being
RCT = randomized controlled trial
RDA = recommended daily allowances
RI = recommended intake
ROC = receiver operating curve
SD = standard deviation
SFA = saturated fatty acid
SHR = service house residents
TEE = total energy expenditure
25-OH-D3 = calcitriol
UL = upper intake level
VRN = Valtion ravitsemusneuvottelukunta (= National Nutrition Council)
WHO = World Health Organization

ABSTRACT

Background: Nutrition among older people is associated with functional ability and quality of life (QoL). Malnutrition is most often observed in institutionalized older people and dependent home-careclients. Furthermore, home-dwelling older people with comorbidities, including Alzheimer's disease (AD), are a risk group for malnutrition. However, few studies have examined the detailed nutrient intakes of older people. In many studies, low nutrient intakes and low diet quality have been observed. Prevention of deterioration in nutritional status is crucial, because poor protein and micronutrient intakes increase the risk of frailty and impaire immunity. As the number of older people increases, more information on nutrition in older populations will be needed. It is important to recognize malnutrition at its early stage and to improve nutrient intake and maintain good nutritional status of older people. The effects of nutritional counseling and education on older people's nutritional status, nutrient intakes, diet quality, and QoL have not been rigorously studied.
Objectives of the study: to determine nutritional status, nutrient intakes and associated factors in both home-dwelling and institutionalized older people at various stages of functioning, and the effectiveness of tailored nutritional counseling and nutrition education on healthy home-dwelling older people's and AD participants' nutritional status, nutrient intakes, number of falls, and QoL .
Subjects and methods: A cross-sectional study (I, II) included institutionalized (n = 374) and home-dwelling older people with varied cognition and mobility (n = 526). Five datasets were combined: home-dwelling older people participating in nutrition education and cooking classes (NC) (n = 54), participants from the Helsinki Businessmen Study (HBS) (n = 68), home-dwelling people with AD (n = 99) and their spousal caregivers (CGs) (n = 97), participants from the Porvoo Sarcopenia and Nutrition Trial (PSNT) (n = 208), and residents of Helsinki assisted living facilities (ALFs) (n = 374). The participants' nutritional status was examined, using the Mini Nutritional Assessment (MNA), and nutrient intakes were retrieved from 1–3-day food records. Data on background information, comorbidities, and cognition were collected. The nutrient intakes were compared with recommended intakes. The adequacy of the nutrient intakes was determined by comparing micronutrient intakes with the average requirements. The sensitivity and specificity of the MNA in identifying older people with low energy and protein intakes were tested. In a follow-up study (III), the effect of NC classes on diet quality, nutrient intakes, and psychological well-being (PWB) was examined in independent and healthy, home-dwelling older people. The Nutrition and Alzheimer 's disease (NuAD) trial (IV, V) was a 1-year randomized controlled trial (RCT) examining the effect of tailored nutritional counseling on home-dwelling AD participants' nutrient intakes, QoL, and risk of falls. Couples received tailored nutritional guidance during home visits in a 1-year follow-up. The primary outcome measure was weight change and the secondary outcome measure comprised changes in protein and micronutrient intakes from 3-day food records, Health-Related Quality of Life (15D HRQoL), and rate of falls among participants with AD.
Results: The groups of older people (I, II) differed in all their background characteristics. The prevalence of malnutrition (17%) and risk of malnutrition (68%) were highest among

the ALF residents, followed by the PSNT group (3% and 60%, respectively). In the other groups, there were no malnourished participants. Among the home-dwelling AD participants, the risk of malnutrition was 43% and among the CGs 16%, whereas the respective figures in the HBS and NC classes were 9% and 7%. Insufficient intakes were most often encountered in the malnourished group, but poor protein and micronutrient intakes were also observed in people with normal nutritional status. Insufficient intakes of nutrients were associated with the female sex, cognitive decline, place of residence (institution), and immobility. Of all the participants, 77% had lower than recommended protein intakes. The participants suffering from mobility limitation and cognitive decline had the poorest nutritional status ($p < 0.001$; adjusted for age, sex, and comorbidities). However, low intakes of energy, protein, and micronutrients were observed in high proportions in all functional groups, those showing inadequate intakes of vitamins D, E, folate, and thiamine being the most common. Higher nutrient intakes were lineally associated with better nutritional status according to MNA, but the sensitivity and specificity of the MNA in identifying suboptimal energy and protein intakes was low. People who participated in NC classes improved their diet quality, PWB, vitamin-C, and fiber intakes postintervention compared with preintervention. The effect sizes varied between small to nearly medium (0.2-0.35). In the NuAD trial, 40% of participants with AD were at risk of malnutrition. There was no difference in weight change between the intervention and control groups during the 1-year study period. At 12 months, the protein intake improved in the intervention group, whereas it declined in the control group ($p = 0.031$, adjusted for baseline value, age, sex, Mini-Mental State Examination (MMSE), and body mass index (BMI). The participants' HRQoL improved by 0.006 in the intervention group and declined by -0.036 in the control group ($p = 0.007$, adjusted for baseline value, age, sex, MMSE, and BMI). The annual rate of falls per person was 0.55 in the intervention group and 1.39 in the control group ($p < 0.001$ adjusted for age, sex, and MMSE). Conclusions: Poor diet quality, insufficient protein, and micronutrient intakes were commonly found in all functional groups of older people. The sensitivity and specificity of the MNA in identifying low energy and protein intakes was low. Tailored nutritional interventions improved diet quality, nutrient intakes, and HRQoL or PWB. In home-dwelling people with AD, falls decreased due to the intervention.

TIIVISTELMÄ

Tausta: Ikääntyneiden ravitsemus on tiiviisti yhteydessä toimintakykyyn ja elämänlaatuun. Virheravitsemuksen prevalenssista on paljon tutkimuksia ja se ovat yleisintä pitkäaikaishoidossa ja kotipalvelun asiakkailla. Ikääntyneiden ravintoaineiden saannista ei kuitenkaan ole riittävästi tietoa. Vähäinen proteiinin ja muiden suojaravintoaineiden saanti lisää haurastumisen riskiä, kiihdyttää lihaskatoa ja heikentää vastustuskykyä. Ravitsemustilan heikkenemisen ennaltaehkäisy ajoissa on tärkeää, koska hyvää ravitsemustilaa tukemalla voidaan edistää aivoterveyttä, toimintakykyä ja nopeuttaa sairauksista toipumista. Väestön vanhetessa tarvitaan lisää tietoa ikääntyneiden ravitsemuksesta, etenkin virheravitsemukseen johtavista tekijöistä sekä keinoja tunnistaa virheravitsemus ajoissa sekä tukea hyvää ravinnonsaantia ja ravitsemustilaa. Ravitsemusohjauksen ja opetuksen vaikutusta ikääntyneiden ravitsemustilaan, ravintoaineiden saantiin ja ruokavalion laatuun ei juurikaan ole tutkittu.
Tutkimuksen tavoitteet: Tutkimuksen tavoitteena oli selvittää kotona asuvien eri kuntoisten ja pitkäaikaishoidon ikääntyneiden ravitsemustila, ravinnonsaanti ja niihin yhteydessä olevia tekijöitä sekä selvittää ravitsemusohjauksen ja -opetuksen vaikuttavuutta tutkittavien ruokavalion laatuun, ravintoaineiden saantiin, kaatumisiin ja elämänlaatuun.
Menetelmät ja aineisto: Kotona asuvien eri kuntoisten ikääntyneiden (n = 526) ja pitkäaikaishoidon asukkaiden (n = 374) ravitsemustila arvioitiin Mini Nutritional Assessment (MNA)—testillä ja ravinnonsaanti 1—3 päivän ruokapäiväkirjan avulla (artikkelit I—II). Poikkileikkaustutkimusten aineistoina käytettiin: Helsingin palvelutaloissa asuvia ikääntyneitä (n = 374), ”Porvoon sarkopenia”- tutkimuksen ikääntyneitä (n = 208), ”Ravitsemus muistisairaan kodissa”- tutkimuksen kotona asuvia iäkkäitä muistisairaita ja heidän puolisohoitajiansa (n=196), Ravitsemustieto- ja ruoanvalmistuskursseille osallistuneita hyväkuntoisia ikääntyneitä (n = 54) sekä ”Helsingin johtaja” -tutkimuksen kotona asuvia ylemmän sosiaaliluokan ikääntyneitä miehiä (n = 68). Tutkittavilta kerättiin lisäksi taustatiedot, tietoja sairauksista ja kognitiosta. Ravintoaineiden saantia verrattiin ravitsemussuosituksiin ja vitamiinien ja kivennäisaineiden riittävyys arvioitiin. MNA:n spesifisyyttä ja sensitiivisyyttä tunnistaa ikääntyneitä, jotka saivat vähän energiaa ja proteiinia ruokavaliosta, testattiin. Ravitsemustieto- ja ruoanvalmistuskurssien interventiotutkimuksessa (n = 54) selvitettiin ravitsemusopetuksen vaikutusta ruokavalion laatuun, ravinnonsaantiin ja psykologiseen hyvinvointiin (artikkeli III). ”Ravitsemus muistisairaan kodissa” (n = 190) (NuAD trial; artikkelit IV—V) vuoden kestävässä randomoidussa interventiotutkimuksessa selvitettiin räätälöidyn ravitsemusneuvonnan vaikutusta kotona puolisonsa kanssa asuvien muistisairaiden ravinnonsaantiin, elämänlaatuun ja kaatumisalttiuteen. Pariskuntia ohjattiin yksilöllisesti kotona tapahtuvalla ravitsemusneuvonnalla. Primaarinen päätetapahtuma oli Alzheimer-potilaiden painon muutos, ja toissijaiset päätetapahtumat olivat muutos proteiiniin ja vitamiinien ja kivennäisaineiden saannissa, terveyden liittyvä elämänlaatu 15D-mittarilla (HRQoL) mitattuna sekä vuoden aikana tapahtuneet kaatumiset.
Tulokset: Poikkileikkaustutkimuksen kääntyneiden ryhmät erosivat toisistaan taustatietojen ja ravinnonsaannin osalta ($p < 0.001$). MNA:lla mitattuna pitkäaikaishoidossa 17%

tutkittavista oli virheravittuja ja 68% virheravitsemusriskissä. ”Porvoon Sarkopenia”-tutkimuksen ikääntyneistä virheravittuja oli 3% ja virheravitsemusriskissä 60%, kotona asuvista Alzheimerin tautia sairastavista 43% ja puolisohoitajista 17% oli virheravitsemusriskissä. Helsingin johtajatutkimuksen iäkkäistä miehistä 9% ja ruoanvalmistuskursseille osallistuneista 7% oli virheravitsemusriskissä. Virheravituilla ravintoaineiden riittämätön saanti oli yleisintä, mutta myös hyvässä ravitsemustilassa olevien ikääntyneiden proteiinin ja muiden suojaravintoaineiden saanti oli tutkimuksissa heikkoa. Kaikista tutkittavista 75% sai suosituksia vähemmän proteiinia. Tutkittavilla, joiden liikuntakyky ja kognitio olivat heikentyneet, oli myös huonoin ravitsemustila ($p<0.001$; vakoitu iällä, sukupuolella ja sairauksilla). Vitamiineista D-ja E-vitamiinin, folaatin ja tiamiinin riittämätön saanti oli yleisintä. Ravintoaineiden riittämätön saanti oli yhteydessä ikään, asumismuotoon, naissukupuoleen, kognitioon ja liikuntakykyyn. Parempi ravintoaineden saanti oli yhteydessä parempaan ravitsemustilaan MNA:lla mitattuna, mutta MNA.n sensitiivisyys ja spesifisyys tunnistaa ikääntyneitä, jotka saivat ruokavaliosta vähän energiaa ja proteiinia, oli heikko. Ravitsemustieto- ja ruoanvalmistuskursseilla osallistuneiden ruokavalion laatu, C-vitamiinin ja kuidun saanti sekä psykologinen hyvinvointi paranivat. Vaikutuksen suuruus (effect size) vaihteli pienestä lähelle kohtalaista (0.2-0.35). Kotona asuvien muistisairaiden proteiininsaanti ja elämänlaatu paranivat sekä kaatumiset vähenivät vuoden kestävän räätälöidyn ravitsemusneuvonnan seurauksena. NuAD tutkimuksessa 40% tutkittavista oli virheravitsemusriskissä. Painon muutoksissa ei ollut tilastollisesti merkitsevää eroa ryhmien välillä. Vuoden seurannan jälkeen proteiinin saanti parani interventioryhmässä ja heikkeni vertailuryhmässä ($p = 0.031$, vakioitu lähtötilanteella, iällä, sukupuolella, MMSE:llä ja BMI:llä). Tutkittavien HRQoL parani interventioryhmässä 0.006, ja heikkeni vertailuryhmässä -0.036 (0.007, vakioitu lähtötilanteella, iällä, sukupuolella, MMSE:llä ja BMI:llä). Interventioryhmässä tapahtui 0.55 kaatumista/henkilövuosi ja kontrolliryhmässä 1.39 kaatumista/henkilövuosi ($p<0.001$ vakioitu iällä, sukupuolella ja MMSE:llä).

Johtopäätökset: Ruokavalion heikko laatu, riittämätön proteiinin ja muiden suojaravintoaineiden saanti oli yleistä kaiken kuntoisilla ikääntyneillä. MNA:n sensitiivisyys ja spesifisyys tunnistaa ikääntyneitä, jotka saivat vähän energiaa ja proteiinia ruokavaliostaan, oli heikko. Räätälöidyt ravitsemusinterventiot paransivat ikääntyneiden ruokavalion laatua ja ravintoaineiden saantia, elämänlaatua sekä vähensivät kaatumisalttiutta kotona asuvilla muistisairailla.

1. INTRODUCTION

The number of older people is increasing rapidly worldwide. It has been estimated globally that the number of people ≥ 60 years of age will more than double from 2013 to 2050 (Department of Economic and Social Affairs 2001). The proportion of older people is also increasing in Finland, with the oldest cohort (those over 85 years of age) increasing most rapidly (Statistics Finland 2015). This demographic change has substantial social and economic consequences, including growth in public healthcare expenditure. However, aging does not directly cause increase in healthcare spending (Tuovinen 2013). The healthier that older people spend their later years, the fewer healthcare services they utilize.

Modifiable lifestyle factors influence the aging process (Steves et al. 2012). It has been estimated that environmental factors account for approximately 75% of the lifespan-influencing factors, and among the most important are quality of food and physical activity (Ozaki et al. 2007, Mangino 2014). Thus, good nutrition throughout the lifespan is a key to healthy aging and longevity (Mathers 2013).

Morbidity and frailty increase with aging (Fried et al. 2001, Morley et al. 2010). Aging, morbidity, and inadequate nutrition contribute to sarcopenia, frailty, loss of functions, and disease progression in older people (Cruz-Jentoft et al. 2009, Morley et al. 2010, Bauer et al. 2013). Malnutrition is common in older people and increases with age and disability (Guigoz 2006, Imoberdorf et al. 2010, Kaiser et al. 2010). Medical conditions, disability, mental disorders, and poor socioeconomic status are among the factors that contribute to nutritional status and its deterioration (Donini et al. 2003). Malnutrition is common in institutionalized older people (Guigoz et al. 2006).

Although malnutrition is most common among older people in hospital and long-term care (LTC) settings, the greatest absolute numbers of those who are malnourished live in the community (Elia et al. 2010). Even in seemingly healthy independent older adults, diet quality has often been poor and nutrient intake low (de Groot et al. 1999, Anderson et al. 2011). Low nutrient intake increases the risk of frailty (Michelon et al. 2006, Bollwein et al. 2013a). Good nutrition is associated with health and reduced risk of cognitive decline. Good diet quality is defined as a balanced diet in accordance with nutrition recommendations that may also reduce the causes of mortality and postpone frailty and disability (Morley et al. 2010, Anderson et al. 2011, McNaughton et al. 2012, Nordic Nutrition Recommendations 2014).

Several studies have examined the prevalence of malnutrition in various older populations, but less is known about diet quality and nutrient intakes in these populations. There are very limited data are available on nutrition interventions, especially on the effects of

nutrition education and tailored nutritional counseling on diet quality and nutrient intakes in community-dwelling (CW) older people.

2. LITERATURE REVIEW

2.1 Aging and nutrition

Successful aging is a multidimensional concept that is characterized by avoidance of disease and disability, maintenance of high levels of physical and cognitive functioning, and sustained engagement in social and productive activities (Rowe and Kahn 1997). Aging of an individual is influenced by genetic and environmental factors. It has been estimated that environmental factors may account for as much as 75% of the aging process (Ozaki et al. 2007, Steves et al. 2012, Mangino 2014). Good nutrition throughout the lifespan supports healthy aging (Mathers et al. 2013). Nutrition has multidimensional effects on cognition, mood, functional ability, and survival (Tolmunen et al. 2004, Morley et al. 2010, Anderson et al. 2011, Safouris et al. 2015). Good nutritional status and diet quality prevent cognitive decline, loss of muscle mass, frailty, and loss of functional ability (Morley et al. 2010, Bauer et al. 2013, Safouris et al. 2015). Nutrition is also important in preservation of normal immune functioning (Lesourd 2004). Essential macro- and micronutrients and trace elements are needed in maintaining the health of individuals and play crucial roles in both immune functioning (Lesourd 2004, Woods et al. 2013, Mocchegiani et al. 2014).

Health issues contributing to the development of malnutrition include oral and dental problems, difficulty in swallowing, gastrointestinal (GI) symptoms, conditions, diseases, and changing nutritional requirements (Hickson 2006, Vuoristo 2010). In addition, metabolic disorders, cancer, infections, and many other diseases may contribute to malnutrition (Vuoristo 2010). Furthermore, unhealthy behaviors may restrict food choices, and alcohol abuse usually limits nutrient intake. Lack of knowledge of nutrition and healthy eating as well as old customs may result in unbalanced and poor-quality-diets. Physical inactivity may contribute to development of malnutrition and it further accelerates the loss of muscle (Bernstein et al. 2012, Bauer et al. 2013). Diseases, stress, and medications may increase energy and nutrient needs and at the same time reduce food intake. Inadequate or suboptimal intake of nutrients in older people is an important issue to address, because poor nutrient reserves accelerate the inflammation process that is associated with aging and diseases causing poor recovery from illness and increases mortality (Morley et al 2010). Protein and micronutrient malnutrition are associated with increased mortality and comorbidity, loss of muscle mass, depression, impaired immunity, skin problems, and poor cognition (Tolmunen et al. 2004, McNaughton et al. 2012, Bauer et al. 2013).

2.1.1 Physiological changes in older people

Body composition

Weight and body composition change with age. As a person ages, the lean body mass and total body water are reduced and total fat increased, even as the body weight (BW) is steady or reduced (Ritz et al. 2008). As the aging process advances, the nutritional needs of an individual change. The need for energy is reduced as the basal energy expenditure (BEE) slows down. The slowdown of BEE is mainly caused by reduced physical activity and subsequent loss of muscle mass. This drop in the activity level in healthy older men may occur sooner than in women (Cooper et al. 2013). Although energy requirements decrease as a person grows older, the process of aging also affects other nutrient needs. While the requirements for some nutrients may be reduced, those for other essential nutrients increase in later life (e.g. protein and vitamin D) (Nordic Nutrition Recommendations 2014). Thus, diet quality is very important, since all essential nutrients should be obtained from smaller amounts of food.

Energy intakes decline after 60 years of age and are reduced by one third in men between the ages of 30 and 75 years and by one fifth in women of the same ages (National Center for Health Statistics 2013). Many older people lose weight and especially fat-free mass, which may lead to sarcopenia and frailty (Fried et al. 2001, Bauer et al. 2013). Furthermore, older people have difficulties in regaining involuntary weight loss (Roberts et al. 1994).

Overweight or even mild obesity can be protective for people over 70 years of age (Flegal et al. 2007, Veronese et al. 2015). Overweight may protect older people from loss of muscle, bone mass, and mortality (Coin et al. 2000, Lau et al. 2005, Flegal et al. 2007). The risk of premature death in different body mass index (BMI) classes has a J-shaped figure (Flegal et al. 2007). The curve shows an increased risk of death of underweight and of very obese older individuals, whereas individuals with overweight or even mild obesity have the highest life expectancies (Flegal et al. 2007). In a meta-analysis by Veronese et al. (2015), not only overweight, but also obesity was protective against mortality in nursing home (NH) residents. Thus, the optimal BMI for older people seems to be higher than that recommended for younger and middle-aged individuals. The optimal BMI for older people is considered to be 24–29 kg/m^2 (Beck and Ovesen 1998, Suominen et al. 2014).

Loss of muscle mass and strength is called sarcopenia. Sarcopenia is defined according to the European Working Group on Sarcopenia in Older Persons (EWGSOP) as decreased skeletal muscle mass, strength, and/or reduced physiological performance. The causes of sarcopenia are multifactorial; the condition may be classified as primary sarcopenia caused by aging or secondary sarcopenia caused by inadequate intake of energy and protein, malabsorption, GI disorders, or by use of medications that cause anorexia (Cruz-Jentoft et al. 2010). It may also be activity-related, due to bed rest or sedentary lifestyle, or disease-related, due to inflammatory diseases, malignancies, or endocrine diseases

(Cruz-Jentoft et al. 2010). Reduction in the levels of anabolic hormones, such as testosterone, estrogen, and growth hormone in older people may be involved in the process of development of sarcopenia (Roubenoff 2000). Sarcopenia itself does not cause weight loss. In fact, sarcopenia is also common in obese older individuals whose fat-free mass has been replaced by fat mass (Goisser et al. 2015a).

Chemosensory acuity

The ability to perceive and to identify food flavors as salty, sweet, sour, and bitter decreases in sensitivity with age (Murphy et al. 2002). Whereas olfaction appears to decline consistently as a person ages, there is varying deterioration of taste perception, with sweet and salty tastes declining first, which causes food to taste sour or bitter (Griep et al. 1995). The main causes that contribute to chemosensory losses include diseases, medications, medical treatment, as well as decline in functional status associated with loss of taste and smell (Clarke et al. 1998). Loss of taste and smell decreases appetite and may alter the food choices selected (Brownie 2006).

Mouth

Poor dentition and ill-fitting dentures are common in older people and lead to chewing and swallowing problems that may limit the type and quantity of foods consumed (Hickson 2006, Tamura et al. 2013, Saarela 2014). Tooth loss is linked with poor oral health, dry mouth, caries, and periodontal disease (Petersen 2008). Decreased saliva production causes dry mouth and increases the risk of caries (Su et al. 2011). Dry mouth is often caused by anticholinergic drugs (Uusvaara 2012). Dry mouth causes pain and dysphagia, thus affecting the nutrient intake of older persons. Loss of chewing function leads to changes in food selection, which may cause limited food choices (Castrejón-Pérez et al. 2012). Soft and pureed foods often reduce nutrient density and nutrient intakes of older people and may provoke weight loss (Petersen 2008, Castrejón-Pérez et al. 2012). About half of the women in Finland and one third of the men over 75 years of age are toothless (Koskinen et al. 2012). Poor oral hygiene results in infections and increases the risk of death (Saarela 2014).

Dysphagia

Dysphagia is common in older people. Some estimates suggest that 15% of older people are affected by dysphagia (Barczi et al. 2000). Some level of swallowing problems may affect up to 40% of institutionalized older people (Humbert and Robbins 2008). Dysphagia is commonly associated with neurological conditions such as stroke, Alzheimer's disease (AD), and Parkinson's disease (Humbert and Robbins 2008). Dysphagia affects food choices, limiting protein-containing foods and vegetables in the diet, and is an independent risk of malnutrition (Takeuchi et al. 2014).

Gastrointestinal tract

Aging impacts the GI tract, which may influence nutrient intake, ingestion, absorption, metabolism, and elimination. Older people often develop disorders of the GI tract, e.g. atrophic gastritis and hypochlorhydria, decreased peristalsis, and altered esophageal

motility (Vuoristo 2010). *Helicobacter pylori* infections are also very common in older people. *Helicobacter pylori* are linked with several diseases, such as peptic ulcer disease, atrophic gastritis, and gastric malignancy and all these diseases affect the nutritional status of older people (Pilotto and Franceschi 2014). It has been estimated that 70% of people over 70 years of age have *H. pylori* infection in Finland (Vuoristo 2010). Atrophic gastritis is most often caused by *H. pylori*. GI conditions often cause weight loss leading to anorexia, micronutrient deficiencies, and increased energy and protein requirements (Donini et al. 2003).

Early sense of satiety may arise, due to more rapidly acting or more potent satiety signals. Early satiation is probably due to a decrease in adaptive relaxation of the stomach fundus, resulting in early antral filling, while increased levels and effectiveness of cholecystokinin play a role in the anorexia of aging (Donini et al. 2003). *Helicobacter pylori* infections may play a role in appetite regulation in older people, thus affecting hunger, satiety, and BW (Salles and Mégraud 2007, Weigt and Malfertheiner 2009). *Helicobacter pylori* infection may cause iron-deficiency anemia in older people, due to blood loss, decreased iron absorption, and increased iron use by bacteria (Pilotto and Franceschi 2014). In atrophic gastritis, the pepsin-acid digestion in the stomach and secretion of intrinsic factor are decreased and bacterial overgrowth in the stomach and proximal small intestine and pH in the latter are elevated. This causes nutrients to be less bioavailable, affecting vitamin B12, calcium, folate, and beta-carotenoid absorption (Krasinski et al. 1986, Russell 2001, Naylor and Axon 2003). In Finland, 12% of people over 65 years of age suffer from vitamin-B12 deficiency, due to malabsorption (Loikas et al. 2007).

Gastroesophageal reflux disease (GERD) is a multifactorial disorder characterized by reflux of acidic gastric contents into the esophagus, leading to tissue damage (Achem and Devault 2014). GERD may also worsen dysphagia and is a commonly encountered disorder in older people. It has been estimated that 20% of older people in Finland have this disorder (Vuoristo 2010)

Constipation

Although constipation is a very common disorder in older people, it is not a physiologic consequence of normal aging (Hsieh 2005). Diseases, polypharmacy, and dietary issues as well as lack of exercise contribute to the increased prevalence of constipation in older adults (Hsieh 2005). Dehydration, inadequate consumption of fiber-rich foods such as fruits, vegetables, wholegrain cereals, seeds, and nuts and lack of exercise are the main causes of functional constipation (Bosshard et al. 2004). In older adults, low intake of fiber is very common (Vikstedt et al. 2011). However, constipation may also be caused by low energy intake in older adults (Towers et al. 1994).

2.1.2 Frailty

The prevalence of frailty and disability increases with age (Fried et al. 2001). Impaired hearing and eyesight commonly occur in older individuals with reduced functional ability

(Keller et al. 1999). As the levels of frailty and disability increase, so do the incidence and consequences of inadequate nutrition (Michelon et al. 2006, Beasley et al. 2010). Inadequate dietary intake of energy and protein causes muscle wasting and weight loss (Morley et al. 2010). As a result, the quality of life (QoL) for malnourished individuals is severely compromised (Rivière et al. 2001). In addition, rising levels of frailty increase the burden on the healthcare system. Frailty is a biological syndrome characterized by low reserves and resistance to stressors and results from cumulative declines in multiple physiological systems of older people (Fried et al. 2001). Progression of frailty is a dynamic process that develops over time and leads to vulnerability and to adverse outcomes, such as disability, poor QoL, and death (Fried et al. 2001, Lang et al. 2009, Berrut et al. 2011. Both undernutrition and obesity contribute to development of frailty (Hubbard et al. 2010). Poor diet quality and poor nutritional status increase the risk of frailty (Bollwein et al. 2013a, b). In fact, frailty is associated with low protein intake, low vitamin D, and deficits in multiple vitamins (Michelon et al. 2006, Shardell et al. 2009, Beasley et al. 2010). Healthy diets are inversely associated with development of frailty (Talegawkar et al. 2012). Frailty may be reversible (Gill et al. 2006). Exercise and nutrition counseling are associated with reduced frailty (Chan and Roberts et al. 2012).

2.1.3 Morbidity

Older people often have chronic diseases that may fundamentally affect their nutrition in various ways. Diseases and polypharmacy may reduce food intake and negatively affect diet quality through changes in food preference, loss of appetite, altered olfactory functions, and altered nutrient metabolism in the body (Brownie 2006). Furthermore, their ability to shop, cook, and eat independently may be compromised (Lechowski et al. 2008). Comorbidities such as stroke, dementia, depression, cancer, arthritis, osteoporosis, microscopic colitis, and visual impairment affect nutrition in various ways. Diseases, stress, and medications may increase energy and nutrient needs, while dietary intake may be reduced due to poor appetite. Cancer patients often experience alterations of taste and smell functions during active treatment that may reduce their appetite and reduce intake of foods. Microscopic colitis causes chronic watery diarrhea and weight loss (Pisani et al. 2016). Depression impacts nutrition negatively in older adults (Tamura et al. 2013). Osteoporosis is associated with sarcopenia and increases the risk of frailty (Verschueren et al. 2013, Li et al. 2015). Chronic illnesses such as diabetes, hypertension, congestive heart failure, and coronary artery disease may be treated with dietary restrictions and with drugs that impact food intake (Evans 2005). The side effects of the medications used may affect the nutrition of an individual by causing anorexia, nausea, and altered taste perception, and they may affect nutrient absorption, metabolism, and excretion (Brownie 2006).

The prevalence of AD increases as the population ages (Brookmeyer et al. 1998). AD is the most common dementia-causing disease (Brookmeyer et al. 1998). Memory functioning is generally affected in AD (Stopford et al. 2012). The stages in AD can be

divided into four categories: early, mild, moderate, and severe, according to the Clinical Dementia Rating (CDR) instrument (Hughes et al. 1982). Even in the very early stages of AD, the nutrition of the patient may be compromised, due to changes in dietary practices and food preferences (Shatenstein et al. 2007). As the disease progresses, functional ability gradually worsens, leading to inability to shop, cook, prepare, and ingest foods (Lechowski et al. 2008). Furthermore, a person suffering from AD may forget whether she/he has eaten. In the later stages of AD, the patient loses the ability to eat independently, may not recognize food, and may show behavioral problems that make feeding difficult (Chang and Roberts 2008). As the disease advances to the severe stage, a person with AD or other dementia-causing memory disorder may develop dysphagia. Finally, severe dysphagia may lead to aspiration of foods and aspiration pneumonia, which is a common cause of death in people with dementia (Chouinard et al. 1998).

2.1.4 Psychosocial issues

The psychosocial reasons contributing to the development of malnutrition include poverty, loneliness, and social isolation (Donini et al. 2003). All these factors cause decreased food intake in older people. Perceived loneliness can profoundly influence nutritional practices, nutrient intakes, and increase the risk of malnutrition (Ramic et al. 2011). Those living or eating alone, especially older men, eat less and are at higher risk of poor nutritional status (Mion et al. 1994). Furthermore, depression, isolation, retirement from employment, and decreased social interaction may have implications for food and eating practices among older people (Ramic et al 2011). Depression is often associated with perceived loneliness or loss of social networks, which may lead to social isolation (Donini et al. 2003). It is a common psychological problem in older people and a significant cause of loss of appetite (Donini et al. 2003). Poverty may cause limited food choices in older people (Dean et al. 2009). Limited access to foods may be caused by inability to shop, prepare foods, and eat independently. Dependency impacts appetite, food choices, nutrient intakes, and increases the risk of malnutrition (Saletti et al. 2005).

Inadequate cooking skills and lack of knowledge of healthy eating, leading to poor-quality diets, may weaken nutritional status (Donini et al. 2013). Older men especially often have poor diet quality that may be caused by lack of nutritional knowledge and cooking skills (Kullberg et al. 2008, Shatenstein et al. 2012, Puranen et al. 2014). Changes in living conditions or unfamiliar living environments, e.g. loss of a spouse or institutionalization, may cause loss of appetite and increase the risk of weight loss (Newman et al. 2001).

2.2 Heterogeneity of functional, health, and nutritional needs of older people

The heterogeneity of functioning and health increases as people age. Older people differ in functional ability and in the number of comorbidities that affect life in many ways. Therefore, older people may have different nutritional needs and nutritional risks, according to their aging process (Suominen et al 2014).

Malnutrition is most common in institutionalized older people, but home-dwelling older individuals may also suffer or be at risk of malnutrition and poor diet quality (Saletti et al. 2005, Suominen et al. 2005, 2009, Kaiser et al. 2010, Soini et al. 2011, Vikstedt et al. 2011). Even among seemingly healthy home-dwelling older individuals, nutrient intakes may not meet dietary recommendations (de Groot et al. 1999). Furthermore, people with AD and their caregivers (CGs) are at special risk of protein and micronutrient malnutrition (Gillette-Guyonnet et al. 2000, Rivière et al. 2001, Shatenstein et al. 2007). Based on comorbidities and functioning, older people can be divided into four groups:

1) Healthy and independent older people that are active, exercise, and engage in social activities. They are often recently retired. A subgroup of this group is spousal CGs who care for their spouse with AD or other comorbidities affecting their dependent's functional ability.
2) Home-dwelling older people that are still independently living but have multiple diseases and are at risk of frailty. They are able to live at home independently without the need for home care. A subgroup of this group includes home-dwelling older people with mild AD. They are at high risk of unintentional weight loss, sarcopenia, and frailty.
3) Home-careclients and home-dwelling older people having several disabilities. They may need assistance with oral hygiene, shopping, cooking, and eating. They may be homebound and often have limited mobility.
4) Institutionalized older people that are frail and have comorbidities and disabilities. They often have cognitive decline and remarkable disabilities and are unable to live at home, even with the aid of home-care services. They need round-the-clock care (Suominen et al. 2010, 2014).

2.3 Nutritional recommendations at various phases of aging

Nutrition guidelines for older people were first published in Finland in 2010 (Suominen et al. 2010). The guidelines point out the differing needs of older people at various phases of aging, due to varying functional ability, comorbidities, and polypharmacy.

Healthy older people: The nutritional needs for home-dwelling healthy older people are similar to those of younger people. Energy intake and expenditure should be balanced and good diet quality is highlighted. Guidelines for diet quality are found in the general nutrition recommendation, which is based on the Nordic Nutrition Recommendation (Nordic Nutrition Recommendations 2014, VRN 2014). Preference for wholegrain products instead

of low-quality carbohydrates is highlighted and salt use is kept moderate. In this group, the psychosocial meaning of dining should also be considered (Suominen et al. 2010). The recommendation stresses that possible weight reduction should be carried out slowly, emphasizing maintenance of muscle mass with a balanced diet combined with exercise. During illnesses, sufficient energy, protein, and micronutrient intake is important (Suominen et al. 2010).

Independent older people with multiple diseases: In addition to the recommendation for healthy home-dwelling people, this group's special focus is the prevention of frailty (Suominen et al. 2010). Healthcare workers should opportunistically identify and prevent weight changes and involuntary weight loss (Morley et al. 2007). CGs are encouraged to organize dining, and a small food reserve should be kept at home in case of acute illness (Suominen et al. 2014).

Home-careclients: This group already has multiple diseases and functional disabilities. In addition to the two recommendations mentioned above, it was further suggested that social and home-care workers plan daily dining, possible shopping services, and meals-on-wheels together with older individuals and their CGs , taking into account each individual's wishes and desires. The need for aid in eating should be assessed and oral hygiene maintained with support of the home-care workers. The psychosocial meaning of dining and pleasure should be considered. It is especially important in this group to prevent unintentional weight loss and weight changes (Suominen et al. 2014).

Institutionalized older people: In addition to the above recommendations, family-style meal times are promoted, in which the dining moment should be calm and older individuals should be able to take their time eating without being rushed (Nijs et al. 2006). Nurses are encouraged to eat together at the same tables with the residents (Nijs et al. 2006, Suominen et al. 2010). The groups of older people, their nutritional risks, and recommendations for each group are presented in Figure 1.

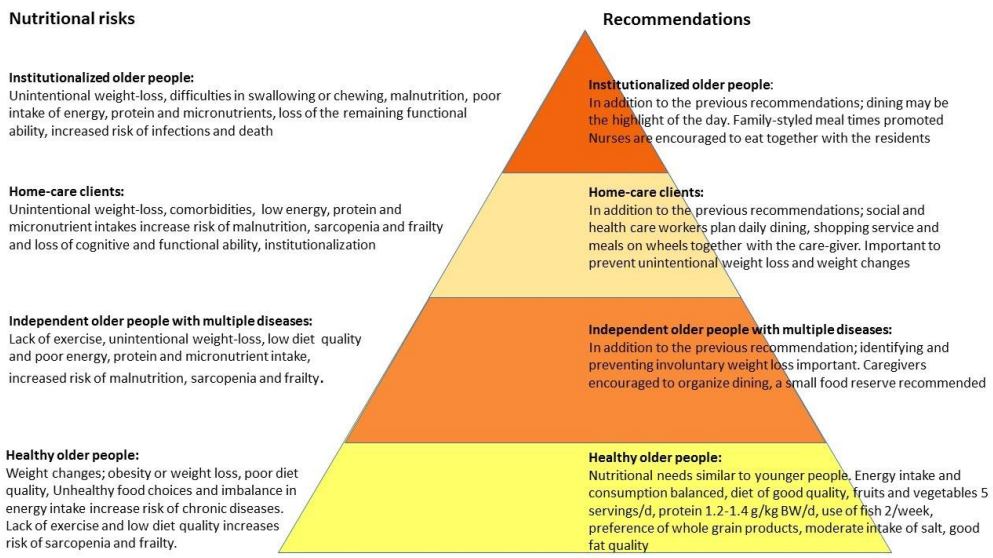


Figure 1. Nutritional risks and recommendations of heterogeneous groups of older populations (adapted from Suominen et al. 2014)

2.4 Recommendations and intakes of energy, protein, and micronutrients in older populations

Energy needs and consumption usually decrease as an individual ages (Vikstedt et al. 2011). This is mainly due to reduced physical activity and loss of muscle mass (Morley et al. 2010). A decrease in the activity level in healthy older men may occur sooner than in women (Cooper et al. 2013). On the other hand, protein and vitamin-D needs may increase (Nordic Nutrition Recommendations 2014, Suominen et al. 2014). Chronic conditions may increase the physiological needs for energy.

2.4.1 Energy needs and recommendations

Energy needs are determined by the energy used. BEE is required for normal functioning of cells, organs and for maintenance of fat-free mass (Food and Agriculture Organization (FAO) 2001). BEE represents about 45–70% of daily energy expenditure, depending on age, gender, body size, and composition (FAO 2001). The physical activity level (PAL) increases energy expenditure by 20–30% and heat production in response to environmental conditions, while eating accounts for 10% of the total energy expenditure (TEE) (Jakicic 2002, Landsberg et al. 2009). The TEE decreases substantially in advanced age, resulting from both changes in resting metabolic rate (RMR) and physical activity (Manini 2010). In normal-weight individuals, the daily TEE falls by 150 kcal every decade and PAL also declines (Roberts and Dallal 2005).

Due to the vast interpersonal variation in energy expenditure, it is difficult to give individual recommendations for energy intakes. Therefore, these recommendations are given at the group level to population groups. Energy recommendations made by different authorities for older people at the population level are generally similar. The European Food Safety Authority (EFSA 2013) published recommendations for energy needs at the population level. For people over 79 years of age, no recommendations were made, due to lack of studies. The recommendations for energy were made according to the activity level. For people 70–79 years of age, the basal metabolic rate for men was estimated to be 1416 kcal and for women 1154 kcal (EFSA 2013). The EFSA recommendation suggested that men with low activity levels need 1984 kcal/d and women 1614 kcal/d. These recommendations are similar to the Finnish Nutrition Recommendations (FNRs) based on the Nordic nutrition recommendation (Nordic Nutrition Recommendations 2014, VRN 2014).

2.4.2 Energy intakes

In the SENECA (Survey in Europe on Nutrition and the Elderly; a Concerted Action) study, which included 12 countries, no single criterion for energy intake ensured adequate micronutrient intakes among CW older people between 75 and 79 years of age, while in those who had an energy intake of 1500 kcal, the micronutrient intakes were inadequate in 19% of men and 26% of women (de Groot et al 1999). People with high energy intakes have in some studies had sufficient micronutrient intakes (Schroll et al. 1996). On the other hand, if diet quality is poor, even higher energy intakes do not guarantee high protein and micronutrient intakes. In some studies, the mean energy intakes have, on average, been lower than recommended (Table 1).

In nine of the studies presented in Table 1, women had mean energy intakes below 1500 kcal/d (Sharkey et al. 2002, Suominen et al. 2004, Leslie et al. 2006, Gariballa and Foster 2008, Johnson and Begum 2008, Paturi et al. 2008, Silver et al. 2008, Helldán et al. 2013, Calvani et al. 2014). The mean energy intakes of a mixed-sex group that did not consume snacks were very low and so was the mean energy intake of another mixed-sex group with low functional ability (Bernstein et al. 2002, Zizza et al. 2007). Hip fracture patients in the hospital and women in dementia wards had especially low energy intakes (Suominen et al. 2004, Calvani et al. 2014). In a study by Shatenstein et al. (2007), a mixed-sex group of AD participants had considerably lower intake of energy than cognitively intact control group. In only three of the studies presented, the mean energy intake in home-dwelling older people was reasonably high, but the participants were also younger or had good functional status (Volkert et al. 2004, Power et al. 2014, Xu et al. 2014).

In a study conducted in Germany that compared two groups of younger and older aged men, the older group had considerably lower energy intake, whereas the energy intake between similar groups of women did not differ considerably (Jungjohann et al. 2005).

Table 1. Studies of energy, protein, and micronutrient intakes of older people in various settings.

Study	Setting	Population characteristics	Mean intake of energy kcal/d Males Females	Mean intake of protein g/d	Mean intake (Males) (Females)		Mean intake of (Males) (Females)		
					Vitamin C, mg	Folate, µg	Vitamin D, µg	Vitamin E, mg	Calcium mg
Xu et al. 2014 China	Home-dwelling independent	n = 2746 53% females age ≥ 60 years	2236 1883	66 55	N.A.		N.A.	N.A.	N.A.
Power et al. 2014 Ireland	Home-dwelling independent	n = 208 55% females mean age 75 years	2008 1668	79 68	96 115	375 358	N.A.	30 28	1056 1272
Helldán et al. 2013 Finland	Home-dwelling independent	n = 413 49% females age 65–74 years	1954 1486	80 62	104 114	255 219	12.8 8.7	10.2 8.5	1056 921
Gariballa and Forster 2008 UK	Home-dwelling independent	n = 61 42% females mean age 77 years	1457	64	58	229	3.0	N.A.	703
Paturi et al. 2008 Finland	Home-dwelling independent	n = 463 51% females age 65–74 years	1848 1412	78 60	92 97	243 210	9.0 6.5	8.7 7.3	1032 900
Zizza et al. 2007 USA	Home-dwelling independent	n = 2002 age > 65 years	1718 (snacks) 1466 (no snacks)	66 61	N.A.	N.A.	N.A.	N.A	N.A

Jungjohann et al. 2005 Germany	Home-dwelling independent	n = 532 70% females age 60–91 years	2300 younger (M) 1880 (F) 2102 older (M) 1826 (F)	16.2 E% younger 17.6 E% 17.1 E% older 17.8 E%	N.A.	N.A.	N.A.	N.A	N.A.
Volkert et al. 2004 Germany	Home-dwelling independet	n = 1372 58% females mean age 77 years (F), 74 years (M)	2207 1994	81 91	117 138	123 111	3.6 2.9		789 782
Nydhal et al. 2003 Sweden	Home-dwelling independent	n = 135 100% females mean age 80 years	1620	N.A.	N.A.	200	4.8	5.9	N.A.
Bernstein et al. 2002 USA	Home-dwelling low functional ability	n = 70 80% females mean age 78 years	1660	66	N.A.	N.A.	N.A.	N.A.	N.A.
Shatenstein et al. 2007 Canada	Home-dwelling AD and healthy controls	n = 58 78% females mean age 74 years	1527 (AD) 1783 (Control)	64 74	227 (Contol) 207 (AD)	591 (Control) 442 (AD)	13 (Control) 11.2 (AD)	7.8 (Control) 5.1 (AD)	964 (Control) 1223 (AD)
Silver et al. 2008 USA	Recipients of home-delivered meals	n = 45 69% females age > 65 years	1423	60	138	474	3.8	8.2	650
Sharkey et al. 2002 USA	Recipients of home-delivered meals	n = 345 81% females age 61–98 years	1572 1325	68 55	93 81	408 346	5.7 4.1	6.8 5.6	773 602
Johnson and Begum 2008 Canada	Home-careclients	n = 98 83% females mean age 82 years	1609 1498	56	124	344	3.0	4.0	628

Leslie et al. 2006 UK	SHRs	n = 34 62% females, mean age 91 years	1426 1592	47 50	51	125	2.7	N.A.	597
Suominen et al. 2004 Finland	SHRs at dementia care unit	n = 23, 100% females mean age 83 years	1205	59	N.A.	N.A.	N.A.	N.A.	N.A.
Calvani et al. 2014 Italy	Hospital, hip fracture patients	n = 62 84% females mean age 85 years	1047 907	55 50 0.88 g/kg BW	N.A.		N.A.	N.A	N.A.

N.A. = not applicable. AD = Alzheimer's disease. SHR = service-house resident. BW = body weight.

2.4.3 Protein needs and recommendations

Adequate protein intake in older people is essential for immunity, wound-healing, maintenance of muscle mass, functional ability, and prevention of sarcopenia (Morley et al. 2010, Bauer et al. 2013). The availability of amino acids is the key determinant of protein synthesis (Pennings et al. 2011). Factors that may affect the bioavailability of ingested protein in older people include insulin resistance, protein anabolic resistance, splanchnic (i.e. gut and liver) extraction, and immobility (Bauer et al. 2013). Insulin stimulates muscle synthesis through increased blood flow and amino acid delivery to the muscle (Rasmussen et al. 2006, Timmerman and Volpi 2013). The splanchnic tissues absorb the alimentary amino acids and release them into the peripheral tissues (Jourdan et al. 2011). If the splanchnic tissues use more amino acids, less amino acids are available for the other tissues (Jourdan et al. 2011). The splanchnic uptake of the amino acids leucine and phenylalanine increase with age (Boirie et al. 1997, Volpi et al. 1999)

Poor protein intake and decreased physical activity lead to loss of muscle mass (Morley et al. 2010). Muscle loss is greatest when protein intake is lowest (Houston et al. 2008). The term sarcopenia is used to indicate the loss of muscle mass and function (Cruz-Jentoft et al. 2010). Chronic and acute illnesses accelerate sarcopenia, and whereas the energy and protein intakes are often inadequate, as a consequence of poor appetite (Covinsky et al. 1999, Inzitari et al. 2011).

The optimal protein intake in older people has been much debated in recent years. There is a widely accepted consensus among scientists that the physiological need for protein increases as a person ages (Morley et al. 2010, Bauer et al. 2013). However, according to the EFSA and Nutritional Guidelines for the recommendation for protein intake for adult population is the same, which is 0.83 g kg BW/d (EFSA 2012) or 0.8 g/kg BW/d (US Department of Agriculture and Forestry 2010). The EFSA and American guidelines base their recommendation on (N-balance) studies in young adults (Rand et al. 2003, Pedersen and Cederholm 2014). However, in the N-balance method using N, it is not possible to precisely determine all the routes of N intakes and losses (Tome and Bos 2000). Furthermore, due to the short duration of the N-balance studies, extended adaption times in older people may result in underestimation of protein requirements (Gaffney-Stomberg et al. 2009). There is evidence that the anabolic response of muscle to dietary protein is attenuated in elderly people, and as a result more protein is needed to achieve anabolic effects. Furthermore, dietary protein increases circulating insulin like growth factor, which has anabolic effects on muscle and bone (Gaffney-Stomberg et al. 2009).

In a study by Campbell et al. (2001), protein intake of 0.8 g/kg BW decreased N-excretion and mid-thigh muscle area in older people. These results suggest that the standard amount of protein recommended for younger people may not be adequate to meet metabolic and physiological needs and preserve muscle mass in older people (Campbell et al. 2001). N-balance may thus not be the correct indicator for

protein balance in older people, because it may not reflect the maintenance of muscle mass (Nordic Nutrition Recommendations 2014).

Exercise combined with adequate protein and energy intake is essential in the prevention and management of sarcopenia (Morley et al. 2010). Results from prospective cohort studies suggest that a safe intake of up to at least 1.2–1.5 g protein g/kg BW/d or approximately 15–20 E% represents an optimal protein intake level (Nordic Nutrition Recommendations 2014).

Due to the increase in protein requirement, the Nordic expert panel increased their protein recommendation by 25% over that of younger adults, although the panel noted that the data supporting this increase is limited (Nordic Nutrition Recommendations 2014). The Nordic Nutrition Recommendation for the protein intake was thus increased by 20% over the previous recommendation (Nordic Nutrition Recommendations 2014). The FNRs based on the Nordic Nutrition Recommendation promotes a protein intake of 15—20 E%, or 1.2—1.4 g/kg BW/d for people over 65 years of age (VRN 2014). The gerontological expert panel known as the protein-aging (PROT-AGE) group proposed a protein intake for healthy older people of 1.0—1.2 g/ kg BW/d (Bauer et al. 2013). Furthermore, in case of acute illness or psychological stress 1.2—1.5 g/ kg BW/d and severe illness, injury or marked malnutrition up to 2.0 g/kg BW/d is recommended (Bauer et al. 2013). In the table 2 dietary protein and some selected micronutrient recommendations by various health authorities are shown.

2.4.4 Protein intakes

The protein intake in most of the studies listed in Table 1 has been low (Bernstein et al. 2002, Shatenstein et al. 2007, Zizza et al. 2007, Gariballa and Foster 2008, Silver et al. 2008). The protein intakes have been lowest, particularly in the frailest of older people, whose protein requirement may be higher than those of older people on average. (Bauer et al. 2013, Calvani et al. 2014, Nordic Nutrition Recommendations 2014) Such groups of older people include hip fracture patients, home-careclients, service-house residents (SHRs), and recipients of home-delivered meals (Sharkey et al. 2002, Suominen et al. 2004, Leslie et al. 2006, Johnson and Begum 2008, Calvani et al. 2014). A study conducted in China reported that less than 20% of the participants met the recommended protein intakes (Xu et al. 2014). However, as the new recommendations were set to be dependent on the BW, it is not possible to compare these findings with the recommendations listed as in most of the studies only total protein intake grams is reported (Nordic Nutrition Recommendations 2014).

2.4.5 Micronutrient recommendations

Vitamin D

Older people are a risk group for vitamin D deficiency. Vitamin D is less bioavailable in older people, and the amount of vitamin D in the average diets of older individuals may be inadequate (Mosekilde 2005, Hamid et al. 2009, Pekkarinen et al. 2010).

Older people and, in particular, institutionalized older individuals, may spend little or no time outdoors, thus their sun exposure is very limited. Moreover, as a person ages, the skin loses some of its′ capacity to produce vitamin D metabolites (Mosekilde 2005). Furthermore, the kidneys' ability to convert vitamin D into bioactive calcitriol (25-OH-D3) is reduced, and the absorption of vitamin D from the gut is decreased (Vieth 2004).

Low vitamin D levels are associated with risk of fractures, poor muscle strength, and increased mortality, whereas vitamin-D supplementation is associated with higher muscle strength, balance, and lower mortality (Muir and Montero-Odasso 2011, Zheng et al. 2013, Bjelakovic et al. 2014a, Schöttker et al. 2014). However, in two cohort studies both low and high concentrations of 25-OH-D3 were associated with increased risk of death (Michaelsson et al. 2010, Durup et al. 2012).

The International Osteoporosis Foundation (IOF) and National Osteoporosis Foundation (NOF) has stated that the estimated average requirements (ARs) of vitamin D are 20-25 µg/d for older people (Dawson-Hughes et al. 2010). However, a considerably higher amount of vitamin D would be necessary to ensure that almost all older adults reach the target plasma vitamin D level of 75 nmol/l (Dawson-Hughes et al. 2010). In the American and Canadian DRI for vitamin D is 20 µg/d (Table 2). The effective dose of vitamin D vary among individuals according to their vitamin D status, BMI, effective sun exposure, and other unknown factors (Dawson-Hughes et al. 2010).The Nordic Nutrition Recommendation expert panel set a plasma target value of vitamin D to 50 nmol/l, since values below increase adverse effects, but the high-end values of plasma vitamin D, according to some epidemiological studies, may also increase mortality (Durup et al. 2012, Michaelsson et al. 2010).

Vitamin E

Vitamin E is a fat-soluble antioxidant, and thus several health benefits have been proposed, due to its antioxidant properties (Nordic Nutrition Recommendations 2014). Dietary vitamin E intake has been associated with lower risk of several chronic diseases, including AD, but supplemental RCTs have not confirmed these results (Lee et al. 2005, Bin et al. 2011, Morris 2012). It has been suggested that dietary vitamin E may function differently in the body due to its presentation in eight natural compounds in natural foods (four tocopherols and four tocotrienols), but in supplements α-tocopherol is the main and usually only form used (Mangialasche et al. 2013). In a Caide study, elevated levels of the tocopherol and tocotrienol forms were associated with reduced risk of cognitive impairment in older adults (Mangialasche et al. 2013). In two cohort studies, higher serum α-tocopherol intakes were associated with lower fracture risk in older women (Michaëlsson et al. 2014). Although vitamin E intakes are often low in older people, clear deficiency of vitamin E is very rare (Nordic Nutrition Recommendations 2014).

Vitamin E recommendations vary somewhat among different authorities (Table 2). The Nordic Nutrition Recommendations for vitamin E are the lowest, whereas

American and Canadian authorities have a considerably higher recommendation, mainly based on the antioxidant activity of the vitamin (U.S. Department of Agriculture and Department of Health and Human Services 2010, Nordic Nutrition Recommendations 2014).

Vitamin C

Vitamin C is a water-soluble antioxidant present in fruits and vegetables. It is involved in several vital biochemical processes in the body, it increases iron absorption, and has immunological effects (Weber et al. 1996). Vitamin C intakes have been linked with positive health outcomes and prevention of various chronic diseases (Carr and Frei 1999). However, studying dietary intakes of vitamin C in association with chronic disease may be misleading, since the benefits of abundant fruit and vegetable intakes have not been attributed only to vitamin C. The supplemental trials with vitamin C are discussed in chapter 2.4.

The current vitamin-C recommendation is based on its antioxidant activity (Nordic Nutrition Recommendations 2014). It is very similar among most authorities (Table 2). Only the Australian recommendation is considerably lower than the others, because it is based on the prevention of scurvy rather than the antioxidant properties of the vitamin (National Health and Medical Research Council 2005).

Folate

Folate is a water-soluble vitamin. Folate status may be negatively influenced by inadequate intake, genetic polymorphisms, and interactions with various drugs (Rampersaud et al. 2003). Inadequate folate status is associated with an increased risk for chronic diseases that. Folate deficiency causes megaloblastic anemia and may have severe neurological consequences on memory (Martin 1988). Furthermore, low folate status has been associated with mood, depression, and increased risk of cognitive impairment in older people (Tolmunen et al. 2004, Castillo-Lancellotti et al. 2012, Petridou et al. 2015). Mean folate intakes across age groups in Finland have been lower than recommended (Helldán et al. 2013). In many countries, e.g. the USA and Canada, wheat flour has been fortified with folate. This practice is not, however, adopted by the Nordic countries. The Nordic Nutrition Recommendations have a lower folate recommendation than other health authorities (Table 2).

Calcium

Calcium intakes are generally high in Finland, due to the abundant use of milk and dairy products (Helldán et al. 2013). Although milk products are the best source of calcium, they are also a major source of good-quality protein, vitamin D, and iodine. Sufficient calcium combined with vitamin D has beneficial effects in maintaining bone mass and preventing osteoporosis in older people (Tang et al. 2007). However, in a recent systematic review dietary calcium intake was not associated with fracture risk (Bolland et al. 2015). High amounts of dietary calcium combined with calcium

supplement use may have adverse health e.g. vascular calcification (Reid et al. 2010). Calcium recommendations for older people vary considerably among health authorities (Table 2). The Nordic Nutrition Recommendation for calcium intake is the lowest.

2.4.6 Micronutrient intakes

The mean vitamin D intakes in all of the studies listed in Table 1 have been lower than recommended, with the exception of a study conducted in Finland, in which the mean intake in older men was in line with the recommendations (Sharkey et al. 2002, Nydhal et al. 2003, Volkert et al. 2004, Leslie et al. 2006, Gariballa and Foster 2008, Johnson and Begum 2008, Silver et al. 2008, VRN 2014). The Finnish recommendation is lower than in most of the other recommendations for people < 74 years of age (10 µg/d). The average intake of vitamin D has increased in Finland from 2008 to 2013 by 34–42%, mainly due to vitamin D fortification of milk products (Paturi et al. 2008, Helldán et al. 2013). In a study by Shatenstein et al. (2007) in which both dietary and supplemental intakes of vitamin D was included, the vitamin D intake was highest, but did not, however, meet the Canadian recommendation (Shatenstein et al. 2007).

Vitamin E intake has been reported in seven of the studies listed (Sharkey et al. 2002, Shatenstein et al. 2007, Silver et al. 2008, Paturi et al. 2008, Johnson and Begum 2008, Helldán et al. 2013, Power et al. 2014). Of these studies, the vitamin E intakes were lowest in the most vulnerable groups of older people, such as home-careclients, home-dwelling AD patients, and recipients of home-delivered meals (Sharkey et al. 2002, Shatenstein et al. 2007, Johnson and Begum 2008). On the other hand, in a study carried out in Ireland with healthy volunteers, the vitamin E intakes were considerably higher than in the other studies reported in Table 1 (Power et al. 2014). Folate intake was generally lower than recommended in the studies listed in Table 1, except for those from the USA, Canada, and Ireland, where wheat flour products are fortified with folate (Sharkey et al. 2002, Shatenstein et al. 2007, Johnson and Begum 2008, Silver et al. 2008, Power et al. 2014).

The mean vitamin C intakes have generally been in line or above recommendations in the studies listed in Table 1. In two of the studies originating from the UK, the mean intakes of vitamin C were below the recommendations in home-dwelling older people and in SHRs (Leslie et al. 2006, Gariballa and Foster 2008). The mean calcium intakes were low in four studies, although they still attained the AR, according to the Nordic Nutrition Recommendations (Sharkey et al. 2002, Leslie et al. 2006, Johnson and Begum 2008, Silver et al. 2008, Nordic Nutrition Recommendations 2014).

Table 2. Dietary protein and micronutrient intake recommendations for older adults, according to various authorities.

Reference dietary intake (RDI)	EFSA[1]		RDI USA 2010[3]	RDI Canada[4]	WHO[5]	RDI Australia[6]
Protein g/ kg BW/d	0.83	1.2—1.4	0.8	0.8	0.9—1.1	0.94/1.07
Vitamin C mg males/females		75	75/90	75/90		45
Thiamine mg males/females		1.0/1.2	1.1/1.2	1.1/1.2		1.1/1.2
Folate µg		300	400	400		400
Vitamin A µg males/females		700/900	700/900	700/900	600—700	700/900
Vitamin D µg		10—20[7]	20[8]	20[8]	10—20	15[9]
Vitamin E mg males/females	11/13	8/10	15	15		7/10
Calcium mg	950	800	1200[10]	1200	800—1200	1300
Iron mg		9	8	8	10	8
Zinc mg males/females		7/9	8/11	8/11	3.0—9.8/4.2—14[11]	8/14

[1] European Food Safety Authority (EFSA 2012, 2013, 2015)
[2] Finnish Nutrition Recommendations (FNR) 2014, based on the Nordic Nutrition Recommendations (Nordic Nutrition Recommendations 2014, VRN 2014)
[3] U.S. Department of Agriculture and Department of Health and Human Services 2010
[4] The food and nutrition board of the institution of Medicine and Health Canada[5] World Health Organization (WHO 2002)
[6] Dietary Guidelines of Australians (National Health and Medical Research Council 2005)
[7] A vitamin-D intake of 10 µg/d is recommended for individuals 61–74 years of age, and a total intake of 20 µg/d is recommended for those 75 years of age and older (VRN 2014)
[8] For people with little or no sun exposure, an intake of 20 µg/d is recommended as a daily supplement for people > 70 years of age
[9] Adequate intake (AI) for people > 71 years of age [10] > 70 years of age
[11] depending on the bioavailability of zinc

2.5 Dietary trends in older people in Finland

The national Health Behavior and Health among the Finnish Elderly survey, which is carried out biennially, has shown that the overall food habits of people between 65 and 84 years of age have improved during the research period (Helldán and Helakorpi 2014). These positive changes include increases in fruit, vegetable, and berry consumption. In the long run, the consumption of saturated fats (SFA) has decreased, although recently there has been an increase in the use of butter-oil spreads, and thus older people consumed more saturated fats than recommended (Helldán et al. 2013). Furthermore, physical activity has increased among older people, according to the survey. However, alcohol consumption and smoking have increased, particularly in the youngest groups of older people between the ages of 65 and 69 years, and abstinence from alcohol has decreased in this age group (Helldán and Helakorpi 2014). Alcohol consumption, especially in women, has increased in recent years (Airola et al. 2013).

In the age group of 65–74 years, dietary micronutrient intakes were similar to those of younger people (Helldán et al. 2013). In this age group, the mean folate and vitamin D intakes in women were lower than recommended (Helldán et al. 2013).

Although diets as a whole seem healthier than before, the number of warm meals used by the participants decreased. According to the study, nearly all of the participants consumed breakfast and lunch, but not dinner (Holstila et al. 2012, Helldán and Helakorpi 2014).

Use of vitamin supplements was common among older people. Among older people in Finland, 41% of the men and 65% of the women used vitamin D supplements during the past year (Holstila et al. 2012). During the last 10 years, the use of supplemental micronutrients and fish-oil products has increased significantly (Savikko et al. 2014). One fourth of the men and one third of the women used micronutrient supplements, and increasing age and comorbidities were associated with increase in supplemental use (Savikko et al. 2014). Married men used more micronutrient supplements than unmarried men (Holstila et al. 2012). The most commonly used supplements were vitamin D and calcium (Savikko et al. 2014).

2.6 Diet supplementation

It is recommended that essential macro- and micronutrients, as well as antioxidants, should be obtained primarily from foods rather than from dietary supplements (Nordic Nutrition Recommendation 2014). Epidemiological studies have consistently shown that consumption of whole foods, such as fruits, vegetables, berries, whole grains, nuts, and vegetable oils are strongly associated with reduced risk of chronic diseases, especially cancer and cardiovascular disease (CVD) (Liu 2004, Nordic Nutrition Recommendations 2014).

In vulnerable multimorbid older people, energy and nutrient intakes from natural foods may, however, be insufficient due to poor dietary intake, diet quality, possible malabsorption and increase of physiological needs (Suominen et al. 2004, Loikas et al. 2007, Bauer et al. 2013, Calvani et al. 2014, Suominen et al. 2014). Therefore, adjustments should be made for the diet of an individual at risk of malnutrition. This may be done by fortifying served foods with energy, protein, and micronutrients, by supplementing additional energy and protein, or by a combination of both strategies. Energy and protein supplementation have been used, especially in hospitalized and institutionalized older people at risk of malnutrition (Cawood et al. 2012, Hanson et al. 2011).

Protein supplementation, often combined with strengthening exercise, has been studied for prevention of muscle loss and strength in older people (Finger et al. 2015). So-called medical foods have been researched in association with AD (Mi et al. 2013). Micronutrient and antioxidant supplementations have been extensively studied for prevention of various chronic diseases, cognitive decline, or for decreased mortality risk (Bjelakovic et al. 2012, 2014a, Hankey et al. 2013).

Energy and protein

Malnutrition is common in institutionalized and hospitalized older people (Guigoz 2006). The effects of oral nutritional supplements (ONS) have been studied in several vulnerable groups of older people (Cawood et al. 2012). ONSs are cost-effective and have increased the QoL in malnourished older people (Norman et al. 2011). In a systematic review, high-protein supplements administered to various types of patient groups and health settings had clinical, nutritional, and functional benefits and did not suppress normal food intake (Cawood et al. 2012). Nutritional care studies using ONSs are reviewed in more detail in chapter 2.9.1.

Physical functioning of older adults improved with protein-containing ONSs, even without physical training (Tieland et al. 2012). The results of muscle mass and strength in association with strengthening exercise and protein supplementation in older people are, however, conflicting (Finger et al. 2015).

Medical nutrition products

Souvenaid® is a medical nutrition product developed to support synapse formation and functioning in early AD (Ritchie et al. 2014). The product contains vitamins C, E, B6, B12, selenium, folate, omega-3 polyunsaturated fatty acids (PUFAs) (docosahexaenoic acid and eicosapentaenoic acid), uridine monophosphate, choline, phospholipids, and acetyl-L-carnitine (Schelte's et al. 2010). Souvenaid® has shown cognitive benefits in patients with mild AD, but has failed to do so in people with moderate AD (Richie et al. 2014). In two randomized, double-blind, controlled trials (duration 12 and 24 weeks) in drug-naive individuals with mild AD, Souvenid improved memory performance (Richie et al. 2014). On the other hand, no effect on cognitive decline was observed in an RCT supplementing Souvenaid for 24 weeks for individuals with mild to moderate AD (Shah et al. 2013).

Micronutrients

A systematic review showed that vitamin D3 may decrease mortality in both independently living and institutionalized older people (Bjelakovic et al. 2014a). In a meta-analysis of prevention of falls and hip fractures among institutionalized older people, vitamin D supplementation reduced fractures (Bischoff-Ferrari et al. 2009). However, studies of vitamin D supplementation in association with cancer prevention have been conflicting (Bjelakovic et al. 2014b).

Vitamins E and C supplementation did not affect the risk of total cancers, prostate cancer, or other site-specific cancers (Wang et al. 2014). No evidence to support antioxidant supplements for primary or secondary prevention of mortality was found in a systematic review and, in fact, β-carotene, vitamin E, and higher doses of vitamin A seemed to increase mortality (Bjelakovic et al. 2012). Vitamin E and C supplements blunted increases in total muscle mass of strength training in older men compared with a placebo group (Bjørnsen et al. 2015).

Daily supplementation with folic acid, vitamin B6, and vitamin B12 of cognitively unimpaired patients with previous stroke or transient ischemic attack lowered their mean plasma homocysteine concentration, but did not affect the incidence of cognitive impairment or cognitive decline in a meta-analysis (Hankey et al. 2013). However, a modest benefit of folic acid supplementation in stroke prevention was observed in a meta-analysis (Yang et al. 2012). Little evidence of a beneficial effect was shown from taking B vitamins or antioxidant supplements on global cognitive functioning in later life (Jia et al. 2008). No effect on cognition or stroke prevention was observed in a meta-analysis in which the participants were supplemented with folate and vitamins B12 or B6, alone or in any combination (Clarke et al. 2014).

2.7 Assessment of nutritional status and dietary intakes

Older people are prone to unintentional weight loss, loss in muscle mass, and development of frailty (Fried et al. 2001, Bauer et al. 2013). The Finnish Nutritional Guidelines for older people have shown that nutritional status and dietary intakes of older people should be assessed regularly (Suominen et al. 2010).

2.7.1 Nutrition assessment methods

Various nutritional assessment tools have been designed and validated for assessment of the nutritional status of older people. These tools include the Mini Nutritional Assessment (MNA), including a short form (MNA-SF) and complete MNA (Vellas et al.1999), Malnutrition Universal Screening Tool or MUST (Stratton et al. 2006) and Seniors of the Community: Risk Evaluation and for Eating and Nutrition (Keller et al. 2005), Simplified Nutritional Appetite Questionnaire (Kruizenga et al. 2010), and Nutritional Form For the

Elderly (Söderhamn and Söderhamn 2001, 2002). Many other tools for screening and assessment of nutritional status in older people have also been developed.

The MNA is the most popular and most frequently used screening and assessment tool (Vellas et al. 1999). Its internal consistency, interobserver reliability, and validity are acceptable (Amella 2008). Furthermore, the MNA is characterized as being user-friendly, quick, noninvasive, and inexpensive (Amella 2008). Lately, a self-MNA has also been developed and validated for older individuals to determine their nutritional status themselves (Huhmann et al. 2013). The advantage of the MNA is that it identifies older individuals at risk of malnutrition at an early stage (Vellas et al. 1999). It has been validated both in institutionalized and home-dwelling older people over 65 years of age (Guigoz 2006). The MNA correlates well with clinical assessment indicators of nutritional status, such as albumin level, BMI, energy intake, and vitamin status (Guigoz et al. 2002). Furthermore, a low MNA score may predict hospital stay outcomes in older patients and may be used to follow up changes in nutritional status (Guigoz et al. 2002). The European Society of Clinical Nutrition and Metabolism (ESPEN) recommends using the MNA in assessing older adults' nutritional status (Kondrup et al. 2003).

2.7.2 Dietary assessment methods

Diet is a major lifestyle-related risk factor for adverse health outcomes. Dietary assessment has become increasingly important in epidemiological and clinical trials. In contrast to other lifestyle factors, such as smoking, dietary exposures can be challenging to measure (Shim et al. 2014).

Dietary assessment methods can be divided into prospective or retrospective methods (Table 3). Prospective methods record current dietary intake and retrospective methods past dietary intake. The prospective methods include food diary, direct observation, duplicate portion collection, and analysis. The most-used retrospective methods include the food frequency questionnaire (FFQ), 24-hour recall, and dietary history methods.
A food diary is usually kept for 1—7 days (Medical Research Council 2014). The method can be divided into a weighed food diary and estimated food records. In the weighed food diary, all foods and drinks consumed are weighed at the time of consumption. This method provides precise portion sizes. However, the method is expensive, time-consuming, and labor-intensive for both participants and for researchers. In estimated food records, the portion sizes are estimated (Medical Research Council 2014). Household measures or natural unit sizes (e.g. slices of bread, fruit, egg) are utilized. At the end of the assessment period, a trained interviewer goes through the records with the individual to clarify details. CGs or nurses may complete diaries in older people who are unable to keep a food diary themselves. The reliability of the food record method increases when several days are recorded. At the individual level, the daily variation in the foods consumed may cause systematic error in energy and nutrient intakes (Medical Research Council 2014). The major flaw of the diet record method is the possible under- or overreporting of the foods consumed. Older people often have similar diets, and the food record in studies is a useful

way to record older people's dietary intakes (Thompson and Byers 1994, Gariballa and Foster 2008). Furthermore, even 1-day diet records at the group level can be used to estimate the dietary intake of a group (Basiotis et al. 1987).

In the dietary intake method, a trained observer notes the individual's food consumption. This method has been utilized in SHRs in Finland to record their dietary intake (Vikstedt et al. 2011). The method is expensive and highly intensive for the researchers.

The FFQ assesses habitual diets by inquiring into the frequency of food or specific food groups consumed over a period of time, e.g. 2 months to 1 year. The foods listed should be major sources of a group of nutrients of particular interest or foods that contribute to the variability in intake between individuals in the population and are commonly consumed in the study population. The number of food items may range from about 20 to 200 items (Medical Research Council 2014). FFQs are commonly used in epidemiological studies. Overestimation is common for foods eaten less often or for those perceived as healthy foods (e.g. fruits and vegetables). Long food lists may increase overestimation of food groups (Medical Research Council 2014). The FFQ is a suitable method for older people, since it does not rely on short-term memory and involves relatively short respondent burdens, compared with many other dietary assessment methods (Smith et al. 1998).

In the dietary recall method, individuals are interviewed about their food and beverage consumption during a defined period of time, typically the previous day or the preceding 24 hours. The recall method relies on short-term memory and is thus problematic for use in older people (Medical Research Council 2014).

A dietary history is a structured interview method consisting of questions about the habitual intake of the main food groups in the last 7 days. This is followed by a cross-check to clarify information about the usual intake in the past 3, 6, or 12 months, depending on the aims of the assessment. The dietary history method has been used in older people, since it does not rely on short-term memory; e.g. in the SENECA study, a modified dietary history method was used to estimate the dietary intakes of 80-year-old study participants (Pedersen et al. 2001).

Despite the fact that various dietary assessment methods are used, all of them have flaws. The most common problem in these methods is considerable over- or underreporting of the foods consumed. In Table 3 the most often-used dietary assessment methods along with their strengths and limitations are presented|

Table 3. Dietary assessment methods and their strengths and limitations*

Method	Strengths	Limitations
Record method - records prospective food intake		
Food record/diary Weighed Estimated	- Does not rely on memory - Provides information on amounts of foods, preparation, and timing of the meals - Weighed method provides precise portion sizes - Probably one of the most reliable methods for assessing nutrient intakes	- Requires literate and numerate skills and ability to measure/estimate amounts of foods - Sex difference exists (women more competent) - Over- or underreporting common - High cost and respondent burden - Food data composition limited - Suitable for older people
Observation of dietary intake	- Objective observation by trained staff at the household or institution level - Ease of application among those who prepare most meals at home - Does not require literacy skills	- Individual dietary consumption not accurate; not suitable among those frequently eating outside the home - Has been used for service-house residents - Expensive, highly intensive for researchers - Individual may alter his/her eating habits - Can only be done at certain times
Recall methods -record retrospective food intake		
24-h recall	- Quick - Easy, low respondent burden - Inexpensive - Useful in clinical setting - Suitable for large-scale surveys - Good reliability between interviewers	- Relies on short-term memory, in older people may be unreliable - May not represent usual intake or reflect nutrient intake in populations - Tendency to over- and underreport - Selective forgetfulness (fat, sweets, alcohol) - Requires interviewing skills and extensive training of the interviewers
Food frequency questionnaire	- Low respondent burden - Good overall picture of food intake, consists usually of 50–150 food items - Suitable for large populations - Inexpensive - May be self-administered via mail or the Internet - Assesses habitual consumption over an extended period of time - Useful for studying an association of certain food/foods and disease	- Requires literacy skills, knowledge of portion sizes - No meal pattern data, day-to-day variation, longer-term periods of intake, or quantity estimations of specific nutrients - Researcher must know the current diet before being able to develop an appropriate questionnaire - Relies on respondent's memory - Respondents may overreport 'good' foods, underreport 'bad' foods -A comprehensive list of all foods eaten cannot be included and reported intake is limited to the foods contained in the food list - Suitable for older people
Dietary history	- Good description of usual diet - Good for longitudinal studies - Observes seasonal variation - Energy and most nutrients can be estimated with reasonable precision	- Difficult to standardize - Time-consuming - High costs of analysis - Responders may overreport healthy foods and underreport unhealthy foods - Is suitable for older people

*modified from Medical Research Council 2014 and Eskelinen 2014

2.8 Malnutrition in older people

Malnutrition is an imbalance between nutrient need and intake (Rothenberg 2002). Malnutrition may be due to undernutrition, overnutrition, or lack of specific nutrients (Donini et al. 2007). Both undernutrition and overnutrition negatively affect health and longevity (Rothenberg 2002). Malnutrition manifests itself by weight loss, obesity, or clinical deficiencies in micronutrients. Protein-energy malnutrition (PEM) develops when the body's needs for protein or energy or both are not satisfied. The origin of PEM can be primary or secondary. Primary PEM is caused by insufficient food intake, whereas secondary PEM is caused by an underlying disease, such as hypermetabolism (Morley 2010). Unintentional weight loss in older people increases the risk of death, even if a person is overweight (Bales and Buhr 2008). PEM is associated with decreased lymphocyte proliferation and impaired immune response (Lesourd 2004).

Malnutrition in older people can be defined as anorexia or wasting, sarcopenia, and cachexia (Hickson 2006). The loss of appetite and physiological decline with involuntary weight loss is called anorexia of aging (Morley 2001). Anorexia can independently be used to predict mortality (Rolland et al. 2006). Cachexia is a severe wasting disease caused by a variety of illnesses that produce proinflammatory cytokines (Yeh et al. 2008). It is characterized by weight loss, lean and fat tissue loss, reduced appetite, and increased cortisol production in the body (Morley et al. 2007, Thomas 2007). Sarcopenia is described in more detail in chapter 2.1. All these conditions may overlap, and it is thus difficult to distinguish them completely from one another in older individuals suffering from malnutrition (Morley et al. 2011).

2.8.1 Prevalence of malnutrition

As independently living older people are very heterogeneous in health and nutrition, so is the prevalence of malnutrition (Table 4). In the studies presented in Table 4, the prevalence of malnutrition varies between 0% and 13% and the risk of malnutrition between 5% and 57% (Johansson et al. 2009, Söderhamn et al. 2012, Bollwein et al. 2013a, Nykänen et al. 201 Hyun and Lee 2014, Farre et al. 2014, Chien and Guo 2014, Krzymińska-Siemaszko et al. 2015, Chavarro-Carvajal et al. 2015, Burman et al. 2015). In Finland, 15% of independently living people over 75 years of age are at risk of malnutrition (Nykänen et al. 2013). In those studies in which malnutrition was highest, the participants were either very old (mean age 90 years) or had low income (Hyun and Lee 2014, Burman et al. 2015, Krzymińska-Siemaszko et al. 2015). Independent, newly diagnosed AD patients showed prevalence of risk of malnutrition (14%) similar to that of most of the independently living older people, whereas CG-dependent home-dwelling AD patients showed considerably higher prevalence of malnutrition (23%) and risk of malnutrition (59%) (Droogsma et al. 2013, Rullier et al. 2014)

In German home-careclients, the prevalence of malnutrition was 12% and risk of malnutrition 57% (Kiesswetter et al. 2013). In Finland, the prevalence of malnutrition and risk of malnutrition among home-careclients have been 3—8% and 44—48%, respectively (Siljamäki-Ojansuu et al. 2003, Soini et al. 2004)

In service houses (SHs) and LTC hospitals, the prevalence of malnutrition and risk of malnutrition have been considerably higher. In NHs, the prevalence of malnutrition and risk of malnutrition has mostly been between 16% and 28%, and 35% and 65%, respectively (Kaiser et al. 2010, Vikstedt et al. 2011, Donini et al. 2013, Verbrugghe et al. 2013, Borgström-Bolmsjö et al. 2015). In a study done in Spain by Serrano-Urrea and Garcia-Meseguer (2013), the prevalence of malnutrition among SHRs was considerably lower (2.8%). However, these residents were cognitively intact, which may explain the lower prevalence of malnutrition observed (Serrano-Urrea and Garcia-Meseguer 2013).

In hospitals and in LTC residences, malnutrition among the older patients has been between 17% and 57% (Suominen et al. 2009, Soini et al. 2011, Schrader et al. 2014, Goisser et al. 2015b). In a study by Söderström et al. (2014), older people admitted to the hospital showed prevalence of malnutrition or risk of malnutrition of 9.4% and 55%, respectively. Since the hospitals had considerably higher prevalence of malnutrition, newly admitted patients should be given special nutritional support to prevent decline of nutritional status.

Table 4. Prevalence of malnutrition and risk of malnutrition according to the Mini Nutritional Assessment (MNA) in recent studies in different settings and populations of older people.

Study	Setting	Population characteristics	Prevalence %		Other findings and comments
			Risk of malnutrition	Malnutrition	
Burman et al. 2015 Sweden	Indepently living	n = 832 mean age 90 years	40.2	13	BMI may underestimate the prevalence of malnutrition, particularly in women.
Chavarro-Carvajal et al. 2015 Colombia	Independently living	n = 1573 > 60 years	4.6	34.7	Malnutrition was associated with poor health perception, comorbidities, number of medications, and poor cognition.
Krzymińska-Siemaszko et al. 2015 Poland	Independently living	n = 4482 mean age 79 years 48% females	38.9	7.5	Female sex, higher age, unmarried status, living in a rural area, and self-reported poverty independently associated with malnutrition.
Chien and Guo 2014 Taiwan	Independently living	n = 4440 mean age 69.5 years 46.9% females	9.2	1.3	Nutrition is an independent predictor of falls in older people.

Farre et al. 2014 Spain	Independently living	n = 328 mean age 85 years	34.5	-	Malnutrition associated with female sex, disability, increased social risk, and polypharmacy.
Hyun and Lee 2014 Korea	Independently living low income	n = 183	57.4	10.4	Low-income, loss of appetite, and difficulties in meal preparation associated with malnutrition.
Bollwein et al. 2013a Germany	Independently living	n = 206 mean age 75 years 66% females	5.1	-	Close association between frailty syndrome and nutritional status in older persons
Nykänen et al. 2013 Finland	Independently living	n = 696	15	-	Risk of malnutrition common among CW older people.
Söderhamn et al. 2012 Norway	Independently living	n = 2106	13.2	-	Number of persons at risk of malnutrition varied according to the instrument.
Johansson et al. 2009 Sweden	Independently living	n = 579 48% females	14.5	-	Regular and combined assessment with MNA, Geriatric Depression Scale-20, and self-perceived health may prevent the development of malnutrition.
Droogsma et al. 2013 Holland	Independently living newly diagnosed AD patients	n = 312 > 65 years	14.1	-	Assessment of nutritional status should be included in the comprehensive assessment of AD patients.
Rullier et al. 2014 France	CW older people with AD and their CGs	n = 112 mean age AD 80.9 CGs 70.9 years	AD: 58.9 CG: 32.1	AD: 23.3 CG: 5.4	MNA score inversely related to ADL and was strongly and positively associated with the MNA score of CGs.
Kiesswetter et al. 2013 Germany	Home-careclients	n = 296 mean age 80.7 years	57	12	Malnutrition associated with functional measures
Donini et al. 2013 Italy	NH and Independently living residents	n = 718 66% female	female: 40.9 males: 35	female: 26 males: 16.3	Malnutrition associated with inability to shop, prepare and cook meals, low income, distance from shops and inability to drive a car or to use public transportation.
Vikstedt et al. 2011 Finland	SHRs	n = 375 mean age 83 years 82% females	65	21	Assessment-based nutritional care should be carried out in service houses.
Serrano-Urrea and Garci-Meseguer 2013 Spain	NH residents	n = 895	37.3	2.8	Female gender and living in institutions located in the main city were risk factors for malnutrition.

Verbrugghe et al. 2013 Belgium	23 NHs in Flanders	n = 1188	38.7	19.4	Presence of a wound, recent hospitalization, being involved in a tailored nutritional intervention, and poor cognitive state associated with malnutrition. Receiving additional meals provided by family members negatively associated with malnutrition.
Borgström-Bolmsjö et al. 2015 Sweden	NH residents	n = 318 mean age 85 years	40.3	17.7	Prevalence of malnutrition increased over time. Regular evaluation of nutritional status important.
Kaiser et al. 2010 multinational, 12 countries	Hosital Rehabiltation, NH, CW	n = 4507 mean age 82 years 75.2% females	Total: 46.2	Total: 22.8 (H: 38.7, RH: 50.5 NH: 13.8,C: 5.8)	MNA should be recommended as the basis for nutritional evaluation in older people.
Schrader et al. 2014 Germany	Geriatric inpatients	n = 202 mean age 82 years 69.3% females	60.3	29.8	Nutritional status according to MNA was related to ADL as well as to mobility in acute geriatric patients
Söderström et al. 2014 Sweden	Inpatients	n = 1767 ≥ 65 years	55.1	9.4	Full MNA independently predicts preterm death in people ≥ 65 years of age.
Goisser et al. 2015b Germany	Hospital	n = 97	38	17	Poor prefracture nutritional status associated with worsening functionality. Low statistical power.
Soini et al. 2011 Finland	LTC NH SHRs CW	LTC = 1087 NH = 1987 SHR = 1475 CW = 400	SHR: 64.6 LTC: 56 NH: 28.4 CW: 85.5	SHR: 13.4 LCT: 41% CW: 7.8% NH: 60.3	Nutritional status according to the MNA varied among participants in different settings.
Suominen et al. 2009 Finland	LTC hospital	n = 1043 mean age 81 75.2% females	40.7	56.7	Nurses recognized malnutrition in older patients poorly.

AD = Alzheimer's disease, ADL = activities of daily living, CGs = caregivers, MNA = Mini Nutritional Assessment, LTC = long-term care, SHR = service-house resident, CW = community-dwelling, NH = nursing home, RH = rehabilitation hospital.

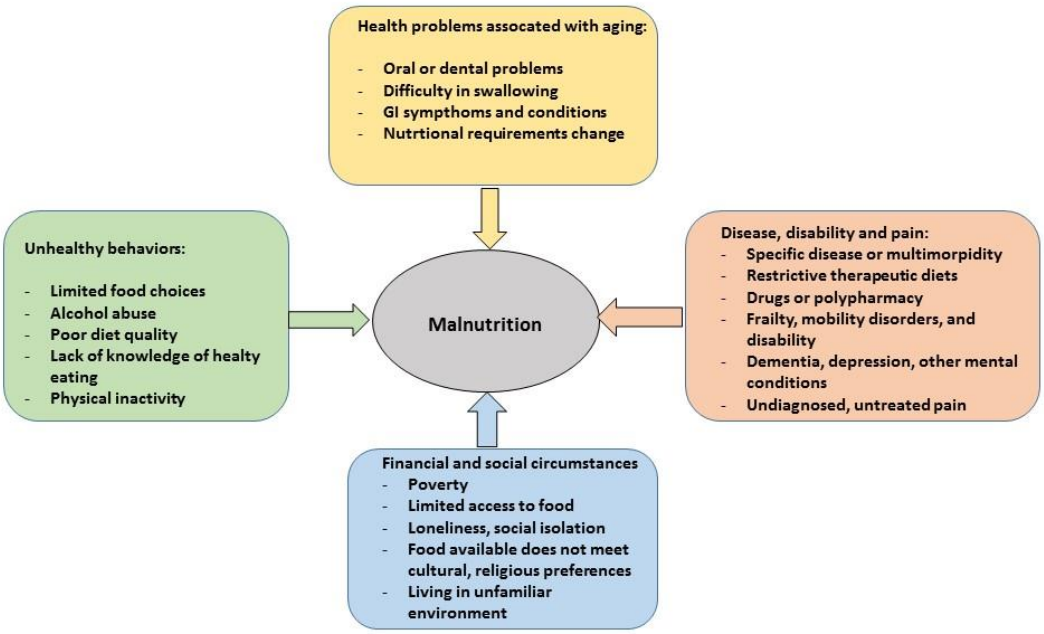
2.8.2 Consequences of malnutrition

Malnutrition is associated with the risk of morbidity and mortality and is a major factor for poor clinical outcome in older people (de Groot and van Staveren 2002, Guigoz 2006, Milne et al. 2009). It aggravates existing diseases, increases complication risk, deteriorates functional status, and increases demand on health services, lengthens hospital stays, readmission, and early institutionalization (Covinsky et al. 1999, Brownie 2006, Agarwal et al. 2013). Malnutrition may precipitate chronic disability and it is also associated with reduced QoL in older people (Rivière et al. 2001, Guigoz 2006).

Weight loss results in increases in circulating toxins, such as insecticides stored in fatty tissue and triglycerides, which increase the formation of the highly atherogenic small low-

density lipoprotein (Morley 2012). Weight loss leads to loss of muscle and bone, which increases the risk of falls, hip fractures, frailty, and disability (Abellan van Kan et al. 2008). Poor nutritional status increases the risk of infectious diseases and results in more serious consequences (Guigoz 2006). The health and psychosocial reasons leading to malnutrition are presented in Figure 2.

Figure 2. Factors contributing to the development of malnutrition in older people.



2.9 Nutritional interventions

Nutritional interventions aimed at older people should be tailored according to the needs and abilities of an older individual. In addition to institutionalized older people, home-dwelling older people with several chronic diseases, such as AD, are also often at risk of malnutrition. On the other hand, healthier and younger older people may also benefit from various educational interventions planned according to their needs and motivation.

2.9.1 Nutritional care

Nutritional care is an important mean for preventing deterioration of nutritional status in older people at nutritional risk. If declining nutritional status is identified and treated in time before advancing to severe malnutrition, it may be reversed (Guigoz 2006). Unintentional weight loss, acute stress, or pre- and postoperative, infections, recovery from illnesses, and fractures are examples in which malnutrition risk is high (Guigoz 2006). Healthcare professionals should identify people in nutritional risk situations and administer high-quality nutritional care (Suominen et al. 2010).

Nutritional care requires the assessment and documentation of nutrient intake of the foods consumed. In two studies, nurses overestimated the amount of foods consumed by LTC patients (Pokrywka et al. 1997, Suominen et al. 2007). Multidisciplinary cooperation is essential for successfully organizing nutritional care (Suominen et al. 2007). The diets of persons at high nutritional risk should be tailored according to each person's individual needs, and the energy, protein, and micronutrient density should be higher than in standard meals (Suominen et al. 2010). Avoidance of unnecessary diet restrictions is recommended. (American Dietetic Association 2005). As protein needs increase during acute stress situations, emphasis should focus on sufficient protein intakes during acute illnesses before and after surgery and in fracture patients (Bauer et al. 2013). Protein and micronutrient supplementation may be necessary in addition to nutrient- dense diets for older individuals with poor appetite or who are at high nutritional risk (Hanson et al. 2011). The role of nursing staffs is crucial in carrying out nutritional care. In an observation study by Simmons and Patel (2006), only 10% of NH residents received the ONSs prescribed to them.

The vast majority of studies of nutritional care have been conducted in the most vulnerable older populations, such as hospital or geriatric ward patients and SHRs, who have for the most part been treated for dementia (Lauque et al. 2000, 2004, Gazzotti et al. 2003, Gil Gregorio et al. 2003, Keller et al. 2003, Young et al. 2004, Salas-Salvado et al. 2005, Parrot et al. 2006, Simmons and Patel 2006) (Table 5). Very few studies have investigated nutritional care in free-living older populations. One such study was conducted by Nykänen et al. (2014). In this 2-year intervention study of home-dwelling older people, nutritional counseling without supplements was given to home-dwelling older

people at risk of malnutrition (Nykänen et al. 2014). As a result of the study, the nutritional status and albumin values of the subjects improved (Nykänen et al. 2014).

Most studies including elements of nutritional care have focused on administering nutritional supplements to institutionalized older people at risk of malnutrition (Lauque et al. 2000, 2004, Gazzotti et al. 2003, Gil Gregorio et al. 2003, Young et al. 2004, Parrot et al. 2006). In a meta-analysis by Milne et al. (2009), protein-energy supplements improved nutrition and reduced morbidity and mortality in malnourished hospitalized patients. In a study by Young et al. (2004), however, those residents with the poorest nutritional status did not benefit from the nutritional supplements. A systematic review by Hanson et al. (2011) showed moderate evidence that high-calorie supplements improve weight in patients with dementia and feeding problems and less evidence that oral supplements promote wound healing and reduce infections. However, no evidence of oral feeding on functioning, cognition, or mortality was found in patients with moderate to severe dementia (Hanson et al. 2011).

Table 5. Summary of nutritional care intervention studies conducted among older people at malnutrition risk.

Study	Setting and design	Population characteristics	Intervention	Outcome
Nykänen et al. 2014 Finland	Independent Intervention	n = 84 ≥ 75 years	A 2-year intervention to improve nutritional status through nutritional counseling	MNA score and serum albumin level increased compared with control group
Simmons and Patel 2006 USA	NH RCT	n = 76 82 years	24-week feeding assistance	Intervention group improved in weight and BMI
Parrott et al. 2006 Canada	Geriatric care facility Randomized crossover design with 10-week follow-up	n = 30 88 years	Energy supplementation containing 250–258 kcal	BMI increased and was sustained after the intervention
Salas-Salvado et al. 2005 Spain	Patients with AD, RCT, 3- month follow-up	n = 56	Lyophilized food diet reconstituted to liquid or semisolid consistency with nutritional advice, controls received nutritional advice only	Weight improvement, no effect on depression scores
Young et al. 2004 Canada	NH Randomized, crossover, nonblinded clinical trial	n = 34 88 years	Nutrition supplements 21 days and compared with 21 consecutive days of habitual intake.	Increased intake of energy, protein, and carbohydrate intake during the supplement phase

Lacque et al. 2004 France	AD patients from geriatric wards and daycare centers RCT	n = 91 79 years	Oral supplements, 150–300 kcal, home visits by dietician, education for 3 months, 6-month follow-up. Control group's care-givers received nutritional education	Weight and BMI increased, no effect on cognition or physical functioning
Gil Gregorio et al. 2003 Spain	Malnourished NH residents RCT	n = 99 86.5 years	Oral supplementation, 1- year follow-up	Weight increased, fewer infections, fewer days in bed
Gazzotti et al. 2003 Belgium	Hospital patients RCT	n = 80 > 75 years	Oral supplementation 500 kcal, 21 g protein/day for 2 months	Intervention group maintained BW and increased MNA score, control group lost weight
Keller et al. 2003 Canada	NH residents with dementia Quasi-experimental design with interventional site and noninterventional site controls	n = 33, control 49 80 years	Enhanced dietician time and care planning, enhanced menu with increased snack foods, high-energy and high- protein foods, 30-month follow-up	Intervention group gained weight
Lauque et al. 2000 France	Malnourished NH residents RCT	n = 78 84–88 years	Nutritional supplements, 300–500 kcal, 60-day follow-up	Malnourished gained weight and increased MNA score Control group: no change in weight No change in grip strength

NH = nursing home. RCT = randomized controlled trial. AD =Alzheimer's disease. BMI = body mass index. MNA = Mini Nutritional Assessment.

2.9.2 Nutritional education

Nutritional interventions focusing on nutrition education have mainly been targeted to specific groups of older people. Nutrition educational programs directed at CGs of home-dwelling individuals with AD positively affected the weight and cognitive functioning of the AD participants, as well as the QoL of their CGs (Rivière et al. 2001) (Table 6). Older colon cancer survivors increased their fruit, vegetable, and fiber intakes (Campbell et al 2009, Bourke et al. 2011). Educational lifestyle interventions targeted at home-dwelling older individuals increased the participants' fruit, vegetable, and fiber intakes (Bernstein et al. 2002, Green et al. 2008, Burke et al. 2013).

In the multidomain RCT of Ngandu et al. (2015), nutrition education and counseling, exercise, and cognitive training were combined with vascular risk factor monitoring and targeted at home-dwelling older people at increased risk of cognitive decline. After 2 years of the study, the intervention group scored better in various cognitive tests. Furthermore, the intervention group adhered to the recommended nutritional changes. In study promoting a Mediterranean diet (MedDiet) combined with nut or olive oil supplementation, intensive nutrition advice was given to various groups (MedDiet + olive oil, MedDiet + nuts or low-fat diet). After 6.5 years of the intervention, the MedDiet groups scored better in cognitive tests than the low-fat group (Martínez-Lapiscina et al. 2013).

The range of effect-size changes on the nutrition education intervention have generally been from low to medium (Potter et al. 2000, Green et al. 2008). Policy interventions or merely spreading information have only shown a weak effect on improving diets or lifestyle habits (Brambila-Macias et al. 2011). Adult learning methods affecting behavioral change have been more effective in improving lifestyle habits (Capacci et al. 2012).

Table 6. Studies of nutrition education in older people.

Study	Participants	Content and aim of the intervention	Outcome
Ngandu et al. 2015 FINGER study Finland	People at increased risk of cognitive decline n = 1260, age 60–77 years	To prevent cognitive decline through a multidomain intervention including nutritional education and counseling, physical activity, memory training, and control of vascular risk factors. Intervention groups; different combinations of strengthening and aerobic exercise.	Intervention group scored better than control group in various cognitive tests
Martínez-Lapiscina et al. 2013 Predimed study Spain	People at high vascular risk n = 522, mean age 74 years	To measure effect of a nutritional intervention using MedDiets on cognition in comparison with a low-fat control diet. Intervention included intensive education and advice to increase adherence to the MedDiet or the low-fat diet, according to group allocation and olive oil (1 l/week) or nut supplementation (30 g/d) to the MedDiet groups.	Cognitive test scores were significantly higher for participants allocated to the MedDiet + olive oil group in comparison with the control group and also in multivariate model in MedDiet + nut group.
Burke et al. 2013 Australia	People with low to medium income n = 176, mean age 66 years	To improve nutrition and physical activity behavior through informative materials, gadgets, and phone contacts	Improvements in nutritional behavior, reduction in sitting time, increase in strengthening exercise
Archuleta et al. 2012 USA	People with type 2 diabetes and their family members n = 117, mean age 63 years	To determine whether cooking classes improve dietary patterns	Improvements in nutrient intake.
Dasgupta et al. 2012 Canada	People with type 2 diabetes n = 72, mean age 60 years	To reduce weight and improve glycemic control and blood pressure through meal preparation and nutritional advice	Improvements in eating control, step count, blood pressure, weight reduction
Shahar et al. 2012 Malaysia	Independent n = 42, mean age 66.5 years	To determine the effectiveness of a nutrition education intervention in improving anthropometric, clinical, and biochemical indicators in people with metabolic syndrome	Triglyceride levels in men and waist circumference in women with metabolic syndrome were reduced

Bourke et al. 2011 UK	People recovering from colon cancer n = 18, mean age 69 years	To improve lifestyle habits through exercise sessions and nutritional pack, seminars, and advice.	Impact on dietary behavior, fatigue, aerobic exercise tolerance, functional capacity, and waist-to-hip ratio
Campbell et al. 2009 USA	Independent n = 735, mean age 66.5 years	To test the effectiveness of two health communication interventions in increasing fruit and vegetable use and physical activity in older adults, including colorectal cancer survivors and noncolorectal cancer-affected individuals.	Increase in fruit and vegetable consumption was found for the combined intervention group in the entire sample. In physical activity, none of the interventions produced statistically significant improvements.
Green et al.2008 USA	Independent n = 834 mean age: 74.7 years	To increase fruit and vegetable consumption Intervention group: exercise only, increased fruit and vegetable use, exercise with diet. Educational training, manuals, newsletters, expert reports, coaching calls	The intervention group increased intake by 0.5–1 servings of fruit and vegetables more than the control group.
Bernstein et al. 2002 USA	Independent n = 69 > 69 years	To increase consumption of fruit, vegetables, and calcium-rich food	An increase in the dietary intake of α-carotene and β-carotene in the nutrition group
Rivière et al. 2001 France	Home-dwelling AD patients and their spousal CGs n = 151 AD and CG	To improve nutrition of home-dwelling older people with AD through nutrition education of spousal CGs.	Positive effect on AD patients' weights and cognitive functioning and CG's quality of life.

AD = Alzheimer's disease. CG = caregiver. FINGER = Finnish Geriatric Intervention Study to Prevent Cognitive Impairment and Disability.

2.10 Summary of the literature review

Older people are very heterogeneous in their cognition, health, and nutrition. As a person ages, many physiological changes (e.g. loss of muscle) occur, and comorbid conditions become more prevalent, which may increase malnutrition risk. The changes in energy and nutrient requirements may be challenging to meet as the energy needs decline, but other nutrient requirements remain stable or may even increase (e.g. protein, vitamin D). Comorbid conditions, infections, and acute stress situations increase physiological energy and nutrient needs, while the appetite may be poor. Furthermore, psychosocial issues such as perceived loneliness, poverty, unhealthy habits, and lack of cooking skills may affect nutrition in a negative way. Polypharmacy itself may affect appetite and absorption of nutrients. Malnutrition is associated with sarcopenia and frailty, which may lead to disability, institutionalization, and increased mortality risk. Good nutrition is crucial to maintaining functional ability, cognition, health, and QoL in older individuals.

Few epidemiologic studies have reported detailed energy, protein, and micronutrient intakes of older people in different settings. Many studies have reported poor diet quality among older individuals. Those who are dependent, comorbid, as well as individuals with AD seem especially to be at risk of inadequate nutrient intakes, weight loss, and malnutrition. Information on nutrient intakes may identify both older population groups and individuals with inadequate nutrient intakes that may thus be at risk of malnutrition.

Nutrition education trials targeted at older people have mostly been directed at specific groups (e.g. cancer survivors, people with diabetes) with mild to moderate effects on the outcome measures. Encouraging results of the FINGER- study outline the importance of an overall lifestyle intervention for cognitive health. Healthy, relatively young older people are an ideal target group for the nutrition education type of intervention, with the objective of preventing nutrition-related risks associated with aging. Very few studies are available of nutrition education targeted at this group.

Nutrition interventions in home-dwelling AD patients living with their CGs are scarce, and no nutritional RCTs prior to our study have been performed in this group of vulnerable older individuals. AD patients have generally benefited from nutritional interventions that have been summarized in Table 5. Since individuals with AD are at increased risk of unintentional weight loss, poor nutrient intake, low diet quality, malnutrition, and falls, they constitute a very important target group that may benefit from a nutritional care type of intervention.

3. AIMS OF THIS STUDY AND RESEARCH QUESTIONS

This study explores the nutritional status, dietary intakes, and effects of nutritional intervention in older people. The specific research questions were:

1. Does nutritional status and nutrient intakes differ between older residents of assisted living facilities (ALFs), home-dwelling independent or dependent older people, and home-dwelling people with dementia and their spousal CGs, and which factors are associated with nutritional status, diet quality, and nutrient intakes (I)?

2. How does a well the validated and widely used MNA questionnaire recognize older people with low energy and protein intakes (II)?

3. Does nutrition education combined with cooking classes improve older participants' diet quality, nutrient intakes, and PMB (III)?

4. Does tailored nutritional counseling affected weight, nutrient intakes, QoL, and number of falls of home-dwelling people with AD (IV, V)?

4. SUBJECTS AND METHODS

4.1 Subjects

The subjects of this thesis were home-dwelling older people with varied cognition and mobility (n = 526) and institutionalized older people residing in ALFs in the Helsinki metropolitan area (n = 374). In cross-sectional studies I and II, the combined data of all of the subjects (n = 900) were used. In study III, the subjects were home-dwelling older people who participated in NC classes (n = 54), and in study IV, the subjects were home-dwelling older people with AD (n = 78) who participated in an RCT aiming to improve their nutrition through tailored nutritional counseling (Table 7).

Table 7. Characteristics of nutrition studies.

Study population	Heterogeneous older populations (I and II)	Healthy home-dwelling older people (III)	Home-dwelling people with AD (IV and V)
Number of participants	900	54	78
Age range	60–99	60–83	60–90
Females, %	66	91	50
Recruitment /gathering of dataset	Five datasets combined	Volunteers were recruited via nutrition lectures, NGOs, and the Internet	Social Insurance Institution of Finland (Kela) retrieved out of its Drug Imbursement Register AD patients living with a spouse at the same address. A recruiting letter was sent by Kela with a reply form. The couples interested in participating were contacted by the investigators.
Inclusion criteria	≥ 60 years of age	≥ 60 years of age	1. A person with AD living together with an aged spouse. 2. Age ≥ 60 years 3. Being able to use transportation (arrive at the study site by taxi) and being able to stand on a scale. 4. Living in the greater Helsinki area 5. Adequacy in Finnish language 6. No diseases leading to death in the next 6 months.
Characteristic of population	1.Institutionalized residents (ALF) 2. Home-careclients (40% of PSNT) 3. Home-dwelling older people with AD and their spousal CGs 4. Home-dwelling older people (NC, HBS, 60% of PSNT)	Home-dwelling healthy older people who were interested in nutrition, health, and cooking.	Home-dwelling older people with AD and their spousal CGs.
Study design	Cross-sectional, descriptive	Pre- and postintervention comparison design	RCT

NGO = Nongovernmental organization, AD = Alzheimer's disease, ALF = assisted living facility, PSNT = Porvoo Sarcopenia and Nutrition Trial, CG = caregiver, NC = nutrition education and cooking class, HBS = Helsinki Businessmen Study, RCT = randomized controlled trial

I, II

Data from five nutritional studies of older people (n = 900) were combined. Of the subjects, 526 were home-dwelling older people and 374 institutionalized residents in ALFs.

The subjects were participants in 1) Nutrition education and cooking classes (n = 54), 2) older men from the (HBS) (n = 68), 3) home-dwelling people with AD (n = 99) and their spousal CGs (n = 97) from the Nutrition and Alzheimer's Disease (NuAD) study, 4) older people screened for the PSNT (n = 208), and 5) residents of ALFs from the Helsinki metropolitan area (n = 374) (Vikstedt et al. 2011). People under 60 years of age were excluded from the study.

The NC participants were healthy independently living older people, mainly women, who were interested in nutrition, health, and cooking. The HBS longitudinal cohort included men from the highest social class, who were either businessmen or management executives during their working lives. They were all independent and living in the community. The home-dwelling AD participants were living with a spouse. They were retrieved from the Social Insurance Institution of Finland (Kela's) Drug Imbursement Register for AD medications. The baseline findings of the intervention study were used in these cross-sectional studies (I, II). The PSNT was a trial examining the effects of protein supplementation and home-based exercises on physical performance among home-dwelling older people at risk of sarcopenia. About 40% of the trial participants were home-careclients. Their baseline findings were used in the studies. Residents of ALFs were those living in the Helsinki metropolitan area.

III

The subjects were participants of NC classes who were interested in nutrition and health issues (n = 54). Volunteers were recruited at nutrition lectures, with the aid of NGOs, and via the Internet. The inclusion criteria of the study included participation in the courses, informed consent, and age > 60 years. The baseline findings of this group were used in I and II.

IV, V

The data of the RCT were collected during 2010—2012. Home-dwelling people with AD living with their spousal CGs were eligible for the trial. They were recruited by Kela. Participants with AD living with a spouse at the same address in the greater Helsinki area were retrieved from the Kela Drug Imbursement Register for AD drugs. The recruitment letter was sent by Kela with a reply form. The couples returning the reply form and showing interest in participating were contacted by the investigators.

The inclusion criteria included: a person with AD (medication with the code 307 by Kela), living together with a spouse, ≥ 60 years of age, being able to use public transportation (arriving at the study site by taxi) and to stand on a scale, living in the greater Helsinki are (Helsinki-Espoo-Vantaa), native or adequacy in the Finnish language, and with no terminal diseases leading to death in the following 6 months. In total, 99 home-dwelling older

people with AD participated in the trial, and 78 completed the trial; thus the final sample consisted of 78 people with AD. The design of the study was described (IV) and the main findings and effects of the RCT reported (V).

4.2 Intervention study designs

The intervention studies consisted of two designs; one was a follow-up investigation and the other an RCT. They are described in detail in the following chapters.

4.2.1 Nutrition education and cooking class study (III)

Home-dwelling older individuals participated in NC classes consisting of three sessions. The inclusion criteria comprised participants filling in the required forms before or at the beginning of the course and being 60 years of age or older during the course. The study participants received by mail a 3-day food diary with written instructions, a validated Index of Diet Quality (IDQ) questionnaire (Mäkelä et al. 2012), and a background information questionnaire, which also included validated questions of PWB (Routasalo et al. 2009). All questionnaires and food diaries were checked at the beginning of the course by the nutritionist. The subjects were weighed, BMI calculated, and nutritional status assessed, using the MNA (Vellas et al. 1999).

Each NC course hosted between 8 and 14 participants, and a total of six courses of three sessions each were held. Each NC class session lasted 4 hours. The meetings started with an interactive nutrition lecture that lasted 1 hour, given by a nutritionist and followed by cooking classes. Their professional cooking instructor taught the cooking classes. The meals were prepared and the ingredients used were culturally familiar to older Finnish people. In each session, a complete menu with various dishes was prepared and each of the participants prepared part of the menu. The menus included salads, fish, meat and vegetable dishes, casseroles, healthy snacks, protein-rich smoothies, desserts made from berries or fruits, homemade bread, etc. The meals were healthy, easy to prepare, and nutrient-dense.

The participants were provided the recipes to take home after the classes. During the course, the subjects received personal oral feedback consisting of a face-to-face session with a trained nutritionist. In addition, the participants received written feedback on their diet. The subjects were given practical advice on how to complement possible inadequacies of their diet and how to improve their diet quality.

The main focus of the nutritional advice was to increase the diet quality of the participants. Good diet quality was considered to comprise generous servings of vegetables and fruits (≥ 5 portions daily), sufficient energy and protein intake of fish, poultry, milk products,

beans, nuts, or egg, good-quality fats, emphasizing the use of vegetable oils, good-quality spreads, nuts, seeds, and fatty fish, whole grains, and low-fat milk products. The participants were also advised to use 20 µg of vitamin-D supplements daily (Suominen et al. 2010). Some of the subjects used calcium supplements excessively, exceeding the upper intake level (UL) for calcium. They were advised to reduce the use of calcium supplements when necessary. All subjects were given written information about healthy nutrition.

At the end of the course, the participants were asked to anonymously give a semistructured feedback on the course. They responded to a questionnaire that contained items using a scale, as well as open-ended questions. After a 4-month follow-up, the subject received by mail a 3-day food diary, the IDQ, and the PWB questionnaire.

4.2.2 Nutrition counseling of home-dwelling older people with Alzheimer's disease (IV, V)

Design
The NuAD study had a randomized design. The intervention lasted for 1 year, and the intervention group was compared with the control group, who received normal community care and, in addition, a written guide on nutrition for older people.
All the participants with AD and their spouses showing interest in participation were first contacted and interviewed by phone to confirm the fulfillment of the inclusion criteria. The couples meeting the study requirements were then invited to the first meeting with a nutritionist. At the first meeting, the couples were given oral and written information on the study and were asked to sign an informed consent. Both the participant with AD and the spousal CG gave informed consent. When the participant with AD showed poor capability of judgment, the spousal CG gave consent for both spouses.

The participants were sent a background information questionnaire and a 15-dimensional Health-Related Quality of Life (15D HRQoL) questionnaire for them to fill in at home and to bring to the first meeting with the nutritionist (Sintonen 2001). The background information included demographic data, diagnoses, and other possible diseases, prior falls, fractures, and current medication. This information was confirmed from medical records provided by the couples in the first meeting.

All participants were assessed at baseline and at the end of the trial. The baseline study meeting lasted about 2 hours. All questionnaires filled at home prior to the assessment were checked and confirmed by a nutritionist. The participants' BW, height, and grip strength were measured and BMI calculated. Nutritional status was assessed with the MNA and a nutritional anamnesis was developed. The cognition of the participants was assessed, using the Mini-Mental State Examination (MMSE) and in addition, the participants with AD were assessed with the CDR by interviewing the spouse (Folstein et al. 1975, Hughes et al. 1982). A trained nutritionist then gave the CG of the home-dwelling people with AD oral and written instructions on how to keep food records for 3

days. They received food measures of 100 ml, 15 ml, and 5 ml to measure the amounts of the foods consumed.

After the completed food records were received, the nutritionist checked them and called the couples to verify the correct amounts, cooking methods, and to confirm that the type of milk, fat, or meat was recorded correctly. The food diaries were analyzed, using the Nutrica 3.11 program developed for this purpose (Rastas et al. 1997). The flowchart of the study is presented in Figure 3.

Randomization
After receiving the food records, the couples were randomized in blocks of six couples. The randomization was performed as follows: investigators recorded the identification (ID) numbers of each couple on a piece of paper, which was then folded so that the numbers could not be seen. A person unrelated to the investigation then blindly removed three papers, and the couples corresponding to these ID numbers were assigned to the intervention group.

Intervention
The intervention group received individualized nutritional care. The nutritionist visited the homes of the intervention group during the intervention and weighed the AD participants with a portable scale at 3, 6, and 9 months. At the baseline and at the final meeting at 12 months, the weights were also measured along with other assessments. The nutritionist analyzed the 3-day food diaries recorded by the couples, and then visited the couples at their homes. Based on analysis of the food diary, nutritional status, nutritional anamnesis, and an initial home visit, the nutritionist formulated a written nutritional care plan for individualized nutritional care according to the needs of the participants.

The written nutritional care plan was then sent to the couples in the intervention group by mail. The plan included practical and concrete instructions on how to complement possible inadequacies of the participant's diets. These issues were then discussed with the nutritionist during the visits at the couples' homes. The nutritionist gave the intervention couples nutritional counseling at their homes four to eight times, depending on the couples' individual needs according to the nutritional anamnesis, food records analyzed, and the initial home visit. The objective of the nutritional care was not to change the AD participants' and their spouses' diet and food habits entirely, but to complement possible limitations of their diet. The couples were recommended those food items they were already familiar with and that were a part of their normal diet. If a clear nutrient inadequacy was detected that was difficult to complement, supplementation was recommended

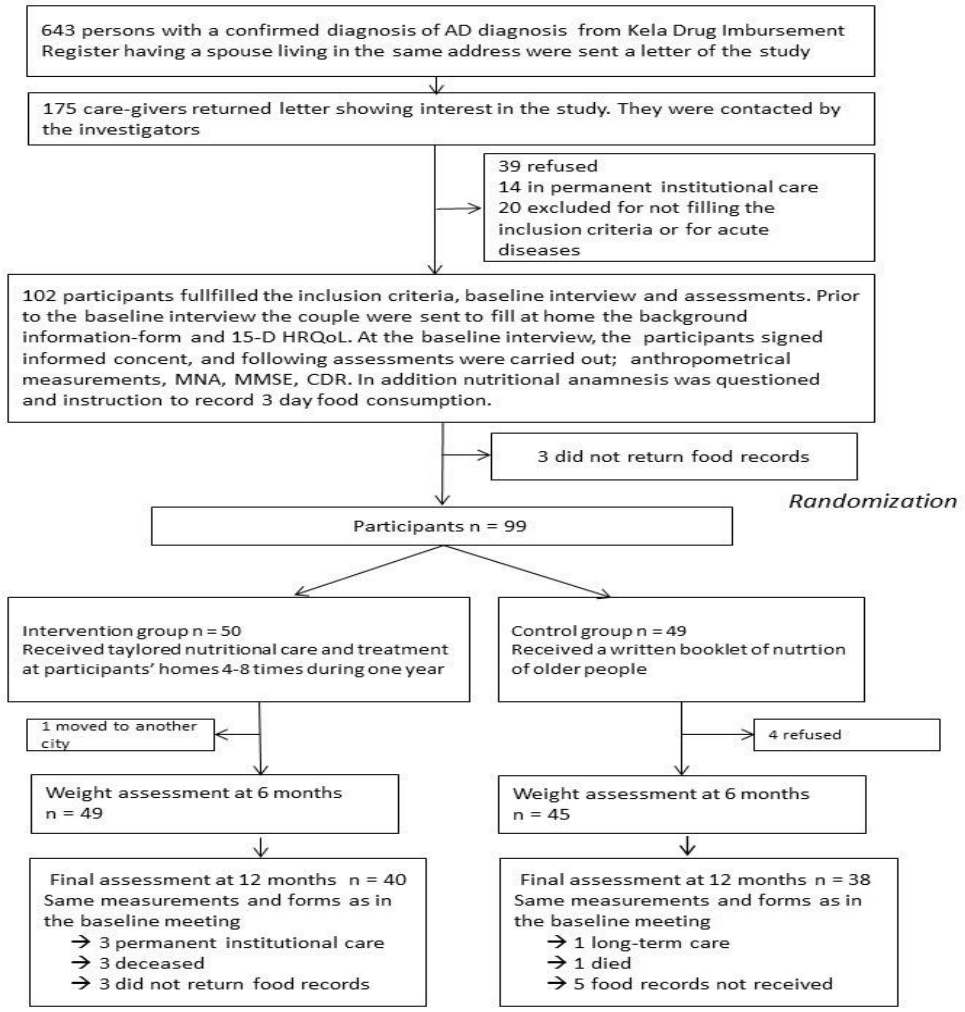


Figure 3. The flowchart of the study IV.

The nutritional counseling had the objective of guaranteeing sufficient intake of energy, protein, and micronutrients. To increase the protein content in the diet, good protein sources were recommended, tips for increasing the protein intake in their daily diet were given, and the couples were given leaflets detailing good protein choices with illustrated examples of the amounts of protein. The main aspects of the intervention are described in further detail in Table 8.

Table 8. Details of tailored nutritional care in the intervention and control groups.

Main aspects of the intervention	Nutrition intervention in the intervention group		Control group
Home visits	Home visit at least once every 3 months, more often if needed; max. 8 times. Nutritional counseling and talks about nutrition.	Baseline measurements and first home visit were the basis for the tailored nutritional intervention. Communication and ability to manage nutrition- related issues were observed	No
Group meetings	1–2 times for each couple.	Program: coffee, examples of healthy snacks, discussions, singing.	After completion of the trial
Use of oral nutritional supplements		Protein- or energy-enriched drinks according to participants' needs based on food records, home visit and nutritionist's estimation of the participants' situation.	No
Tailored nutritional care plan	To each participant. Sent by mail after assessment and the first home visit.	Included feedback from baseline assessments (BW, nutrient intake, cognition, etc.), practical suggestion to increase nutrient intake if necessary, all advice was suitable for AD patient's daily living	After the final measurements
Booklet of nutrition for older people		General information on good nutrition for older people	When allocated to the control group
Brochures with photos of good protein, calcium and vitamin-D sources		Description and images of protein and calcium sources	After completion of the trial

AD = Alzheimer's disease

ONS

If a couple appeared unable to increase their energy, protein, or micronutrient levels or to make simple changes in their diet, ONSs as a complementary drinks containing protein and micronutrients were given to the intervention participants. The brand name of the drinks was Nutridrink protein (200 ml; 300 kcal, 20 g protein) or Nutridrink compact (125 ml; 300 kcal and 12 g protein). The complementary Nutridrink was given periodically when necessary. By the time of the last assessment, no participants were using the ONSs.

The couples were recommended to take 20 µg of supplemental vitamin D daily. The amount of calcium in the diets of the participants was also reviewed. The intervention couples also attended organized group meetings, in which each couple took part once or twice during the intervention, where they were offered coffee, healthy snacks, and healthy nutrition was discussed in the meetings.

Control group
The couples in the control group were weighed at the beginning of the trial and at 6 and 12 months. They received a written booklet on nutrition for older people. After the trial was over, they were also given a written feedback of their diets that included concrete suggestions on how to improve their nutrition. They also attended an organized group meeting after the intervention.

Outcome measures
The primary outcome measure of this trial was weight change in the home-dwelling participants with AD. The secondary outcomes included changes in the AD participants' energy, protein, and other nutrient intakes retrieved from food diaries, 15D HRQoL (Sintonen 2001), the number of falls during the follow-up, and cognition (CDR, MMSE) of the participant with AD (Folstein et al. 1975, Hughes et al. 1982).

4.3 Methods

The data collection methods are described in detail in Table 9. In a study conducted in the ALFs, trained nurses filled in the food records for the residents. The spousal CGs recorded the food records of the AD participants. All the other groups of older people (NC, HBS, CG, and PSNT) recorded their food intakes independently after having received written and oral instructions. Nutrition was assessed by a nutritionist or a nurse using an MNA in all of the studies. Cognition was evaluated by the MMSE (Folstein et al. 1975) or CDR scale (Hughes et al. 1982) through face-to-face interviews.

Table 9. Description of the study methods.

Studies	Methods	Sample size
I and II	MNA 1-3-day food records MMSE and/or CDR CCI Structured questionnaire of background information	n = 900
II	MNA 1-3-day food records CCI, MMSE, CDR Structured questionnaire of background information	n = 900
III	Pre- and postintervention comparison design: nutrition education combined with practical cooking classes. Personal feedback on diet quality and nutrient intakes Questionnaires: MNA Food records (2 x 3-day) IDQ PWB scale Structured background information questionnaire	n = 54
IV and V	RCT: Tailored nutritional counseling 4–8 home visits in 1 year by a nutritionist, nutritional care plan, feedback on diet quality. Daily protein drinks (Nutridrink) tailored for participants in need of extra protein. Questionnaires used in the study: MNA Food records (2 x 3-day) Nutritional anamnesis MMSE, CDR, CCI 15D HRQoL questionnaire, number of falls. Structured background information questionnaire	n = 78

MNA = Mini Nutritional Assessment, MMSE = Mini-Mental State Examination,
CDR = Clinical Dementia Rating, CCI = Charlson Comorbidity Index, IDQ = Index of Diet Quality, PWB = Psychological Well-Being, 15D HRQoL = 15D Health-Related Quality of Life, RCT = randomized controlled trial

4.3.1 Data collection

In the NuAD study, all the questionnaires used (nutritional anamnesis, MNA, MMSE, CDR) in the study were questioned and nutrition assessed (MNA) by a nutritionist (SKJ). She also instructed the CGs in how to fill in the food records. The participants filled in the background information and HRQoL 15D forms at home, both of which were checked at the baseline meeting (SKJ). SKJ and another nutritionist in the study analyzed the food records obtained from the study subjects.

In the NC classes study, the nutritionist (SKJ) instructed the participants in how to fill in the food diaries, questioned the IDQ questionnaire, and assessed their nutritional status with the MNA. The participants filled in the background questionnaire at home and during follow-up; all the forms were sent to them by mail, which were then checked (SKJ). The nutritionist (SKJ) analyzed all the food records in this study.

In the HBS study, the participants filled most of the questionnaires at home and they were then checked by a study nurse, who also instructed them in how to fill in the food diary. SKJ analyzed all the HBS trial food records.

In the PSNT, the participants filled in part of the questionnaires at home (background information), which were later completed and assessed (MNA, MMSE, and CDR) by a doctor. The participants were instructed how to complete the food diaries, which were checked and analyzed by a nutritionist.

In the ALF study, trained nurses observed the residents at the meals and recorded the foods consumed. The nutritional status was assessed (MNA), and the questionnaires were completed by trained nurses. A nutritionist analyzed the food diaries.

4.3.2 Questionnaires used in the studies

Background information on demographic data
A structured questionnaire included information on demographic characteristics (age, gender), diseases, dietary supplements, and number of prescribed medications.

Psychological well-being (PWB)
PWB was measured, using six validated questions (III) (Routasalo et al. 2009). The questions inquired about (1) life satisfaction (yes/no), (2) feeling needed (yes/no), (3) having plans for the future (yes/no), (4) having zest for life (yes/no), (5) feeling depressed (seldom or never/sometimes/often or always), and (6) suffering from loneliness (seldom or never/sometimes/often or always). We used a well-being score developed by Routasalo et al. (2009), in which each question represented 0 (‘no’ in questions 1–4, ‘often or always’ in question 5 or 6), 0.5 (‘sometimes’ in question 5 or 6), or 1 (‘yes’ in questions 1–4, ‘seldom or never’ in question 5 or 6). The score was created by dividing the total score by the number of questions the participant had answered. Thus, a score of 1 represented the best well-being and 0 the poorest.

Charlson Comorbidity Index

The Charlson Comorbidity Index (CCI) predicts mortality for a person with comorbid conditions, such as cancer, heart, or liver disease. Each condition has a weight, depending on how strongly the condition is associated with the risk of death, and the sum of these conditions gives an overall score or index (Charlson et al. 1987, 1994). The CCI includes diabetes, myocardial infarction or heart failure, AD or other dementia-causing diseases, hemiplegia, ulcer, chronic lung disease or chronic obstructive pulmonary disease (COPD), renal insufficiency, cancer, chronic liver disease, and peripheral vascular disease (Charlson et al. 1987).

The disease indices in the CCI usually range from 0 to 9 (Charlson et al. 1987). In the studies, each index was calculated from the diagnoses reported (NC, CG, AD, and HBS) or from diagnoses verified from their medical records by a medical doctor (PSNT, ALF). In this thesis, the CCI was used to indicate the number of diseases.

Mini-Mental State Examination

The MMSE test is used to measure cognitive functional ability (Folstein et al. 1975). It is probably the most widely used test measuring cognitive functioning among older people. It was originally developed to assess psychiatric patients' cognition (Folstein et al. 1975). It is also used to estimate the severity and progression of cognitive impairment and to follow the course of cognitive changes in an individual over time, thus making it an appropriate way to document an individual's response to treatment. The test examines functions including registration, attention and calculation, recall, language, ability to follow simple commands, and orientation. The test score is interpreted as follows: 0—10 points indicate severe dementia, 10—18 points indicate moderate dementia, 18—24 points indicate mild dementia, and 24—30 points indicate normal cognition (Folstein et al. 1975). The MMSE test is not specific for clinical memory disorder. The test is useful for screening, but delirium, dysphasia, apraxia, and sensory limitations may weaken its reliability. A well-educated person can achieve high MMSE scores, even though his/her memory disorder may be advanced (Koivisto et al. 1992). Mild cognitive impairment cannot be screened with this test. The test has also been criticized for not recognizing cognitive changes in advanced AD (Ylikoski et al. 1992).

Clinical Dementia Rating

The severity of memory disorder was examined in NC, HBS, AD, and ALFs, using the CDR instrument (Hughes et al. 1982). The CDR score is based on the estimation of impairment of intellectual and functional ability. The instrument has a 5-point scale used to characterize six domains of cognitive and functional performance applicable to AD and related dementias: memory, orientation, judgment and problem solving, community affairs, home and hobbies, and personal care (Hughes et al. 1982). Each domain is given a rating 0, 0.5, 1, 2, or 3. The overall score is determined, based on memory and other domains that may increase or decrease the overall rating by 1. The necessary information to make each rating is obtained through a semistructured interview of the patient and a reliable informant, such as the CG, family member, or other reliable source. The overall CDR

score is given as follows: 0 = no dementia, 0.5 = very mild dementia, 1 = mild dementia, 2 = moderate dementia, 3 = severe dementia. The CDR instrument has been validated for screening the severity of memory disorders in older people and can reliably exclude moderate to severe dementia (CDR > 1) (Hughes et al. 1982).

Falls
The spousal CGs were asked to record possible falls of the home-dwelling AD participants during the home visits (IV, V). The number of falls was determined at 6 months during the home visit and at the final meeting with the investigators. In addition, the consequences of the falls, such as possible fractures and hospital or healthcare center visits were recorded.

Health-Related Quality of Life
The 15D was used in IV and V. It is a validated, generic, comprehensive, self-administered instrument for measuring HRQoL among adults. It combines the advantages of a profile and a preference-based, single-index measure. A set of utility or preference weights is used to generate the 15D score (single-index number) on a 0—1 scale. In most of the important properties, the 15D compares favorably with other preference-based generic instruments (Sintonen 2001).

The 15D HRQoL has 15 dimensions, including questions about mobility, vision, hearing, breathing, sleeping, eating, speech, excretion, usual activities, mental functioning, discomfort and symptoms, depression, distress, vitality, and sexual activity. The 15D scores are highly reliable, sensitive, and responsive to change, generalizable at least in developed societies, and particularly valid for deriving quality-adjusted life years used for resource allocation purposes. The instrument is recommended by the Washington Panel and is available in several languages for clinical economic evaluation and population studies (Sintonen 2001).

4.3.3 Dietary and nutritional assessments

Nutrition was assessed, using the MNA for nutritional status and food records for intakes of energy, protein, micronutrients, and fiber in all studies. In addition, diet quality was measured, using the IDQ (III). Furthermore, the use of calcium and vitamin-D supplements was determined in all studies.

Mini Nutritional Assessment
All subjects in the studies included were assessed by the Finnish version of the MNA. The MNA gives a maximum score of 30 points and classifies older people (> 65 years of age) as having normal nutritional status, being at risk of malnutrition, and those who are malnourished (Vellas et al. 1999, Guigoz et al. 2006). The MNA questionnaire includes queries on loss of appetite, weight loss, mobility, stress, neurological issues, BMI, place of residence, use of medications, pressure ulcers or other wounds, number of full meals, protein sources in the diet, fruit and vegetable consumption, fluid intake, mode of feeding,

self-perceived nutritional status, health comparison with others of the same age, and arm and calf circumference. The MNA questionnaire has been well validated in various settings and populations and is widely used internationally (Guigoz et al. 2006). The full MNA and 3-day food diary combined with the FFQ was validated in a small study with either hospitalized (n = 105) or independent (n = 50) participants, in which the MNA correlated with nutrient intakes, anthropometric, and biological nutritional parameters (Vellas et al. 2000). A series of validation studies was conducted in over 600 persons, from very frail to robust, ranging in age from 65 to ≥ 90 years. The MNA has also demonstrated significant correlations with albumin levels and with lengths of hospital stay, and low MNA scores have been associated with mortality (Guigoz 2006, McDougall et al. 2015).

Some criticism of the MNA has also been expressed, e.g. the weight criterion (item C) (Amella 2008) and some concern over the self-evaluation questions (items O and P) in demented patients (Sieber 2006). The examiner's familiarity with mid-arm and mid-calf measurements has also been questioned (Amella 2008).

The MNA score is interpreted as follows:
Scores > 23.5 points; a person has a normal nutritional status. The person's BW should be followed up regularly and if significant weight loss occurs, nutritional intervention is needed.

Scores of 17—23.5 points; a person is at risk of malnutrition. Often, these persons may not show significant weight loss or altered biochemical parameters, but may have prolonged lower than the recommended intakes (RIs) of energy, protein, and micronutrients. Therefore, a detailed nutritional evaluation is needed, as well as review of medical history, current diseases, oral hygiene, and swallowing ability. Nutrient-dense meals are recommended and sometimes oral supplements are needed.

Scores < 17 points indicate energy-protein malnutrition. Intensive nutritional care is needed.

Nutritional anamnesis
A nutritional anamnesis was used in V. The questionnaire included queries about the use of nutritional supplements, possible food allergies and food preferences, general food habits, and shopping and cooking habits of the couple. It also included queries about diseases affecting food intake, possible mastification or swallowing problems, oral health, and teething.

Food records
Food records are used to record the foods and beverages and the amounts of each consumed over a period of one or several days by the respondent. The amounts consumed may be measured with a scale or household measures (such as cups, tablespoons) or estimated, using models, pictures, or no particular aid (Thompson and Byers 1994). The dietary record method has the potential for providing quantitatively

accurate information on foods consumed during the recording period (Thompson and Byers 1994).

During the studies, the participants filled in (NC, HBS, CG, PSNT) or had someone fill in the food records for them (AD, ALF) for either 1 day (HBS, PSNT, ALF) or 3 days (NC, CG, AD). Previous research has indicated that food intake data based on 1-day dietary recalls are reliable measures of usual intakes at the population group level (Basiotis et al. 1987).

The food diaries were checked and verified by a nutritionist in face-to-face interviews (NC) or by phone calls (CG, AD, PSNT, and HBS). The ALF residents' dietary intakes were recorded by trained nurses. The nutrient intakes were calculated, using the validated Nutrica 3.11 or Aivo programs developed for this purpose.

Index of Diet Quality

The IDQ was used in study III and it consists of 18 questions scored from 0 to 15 points, including questions on fruit and vegetable intake, fat quality, use of whole grains, use of fish, sugary beverages, sweets, and meal spacing. The defined cut-off point is set at 10, values below indicating nonadherence and scores of 10–15 points good adherence to dietary recommendations. The IDQ was especially designed for Finnish diets. The IDQ shows relatively high sensitivity and specificity in validation against 7-day food records and is suitable for assessing the health-promoting properties of a diet (Mäkelä et al. 2012).

Vitamin-D and calcium supplementation

Information on vitamin-D and calcium supplementation was obtained by the following questions of supplement use: Do you/does the participant use nutritional supplements (yes/no). If yes, what is the quantity of the energy, protein, and micronutrient intakes are presented according to the MNA classes used (AD, CG, NC). Information on quantity was retrieved and checked from medication lists (HBS, ALF, and PSNT). Total calcium and vitamin-D intakes were calculated, including possible supplemental calcium and vitamin D use.

4.4 Data analysis

The data are presented as means with standard deviation (SD) or ranges for continuous variables and as percentages for categorical variables. The differences between the baseline characteristics and dietary intakes of groups were analyzed, using the Chi^2 test or Fisher's exact test for categorical variables and Kruskal-Wallis or analysis of variance (ANOVA) tests (I, II) and the Mann-Whitney U test or t-test (IV) for continuous variables as appropriate.

The dietary intakes among the older population samples were compared with the RIs (Nordic Nutrition Recommendations 2014). Dietary energy intake was compared with the National Nutrition Council's (NNC's) recommendation, since the new Nordic Nutrition Recommendation for energy is determined according to the PAL and most of the participants lacked this information (NNC 2005, Nordic Nutrition Recommendations 2014). The ARs were used as reference values for the adequate intake of micronutrients. Since ARs are not available for energy, protein, fiber, or PUFA intakes, they were compared only with the RIs. Intakes above the upper intake levels (UL) and intakes under low intakes (LI) were also explored. The UL is the upper intake level for micronutrient intakes, and intakes above the UL may lead to adverse health consequences. Intakes below the LI lead to deficiencies of nutrients in almost all people.

The energy expenditure was estimated to evaluate possible bias due to under- or overreporting of foods consumed in this population. The BEE was calculated according to WHO's formula (10.5 x BW + 596 kcal in females and 13.5 x BW + 487 kcal in males) (WHO 1985). The BEE was then multiplied by 1.3 for the general population and by 1.1 for the bedridden older participants. BEE can vary ± 20% between people. Therefore, the means of the lower and upper energy expenditure values were calculated (BEE ± 20%) to obtain acceptable energy expenditure ranges.

The dietary intakes (II) of energy, protein, fats, carbohydrates (total carbohydrates, sugar, and fiber), and key micronutrients were divided according to the MNA classes (normal nutritional status, risk of malnutrition, malnourished). For calcium and vitamin D, the total intake was taken into account, including supplemental use. The relationship between the MNA groups and dietary intakes was analyzed, using the generalized linear model, adjusted for age, sex, and comorbidities. The statistical significance for hypotheses of linearity was evaluated with ANOVA or the Cochran-Armitage test. The receiver-operating characteristic (ROC) curve was constructed to determine the cut-off point of MNA that corresponded to the energy (1570 kcal for females, 2070 kcal for males) and protein intakes (1.0 and 1.2 g/kg BW) and with bias-corrected bootstrap with confidence intervals (CIs). Values for the area under the ROC curve from 0.7 to 0.8 were considered a reasonable discrimination and those exceeding 0.8 good discrimination. The best cut-off point was defined with the highest accuracy that maximizes the Youden's index. Sensitivity, specificity, positive and negative likelihood ratios (LRs), Youden's index, and their 95% CI values were calculated.

Statistical comparison of changes in outcome measurements was performed, using a bootstrap-type t-test (III). The power of this study was fairly low. Therefore, the effect size with CIs was used to illustrate the size of the effect. The strength of dietary change was demonstrated by the effect size ('d'), which was calculated using the method of Cohen for paired samples. An effect size of 0.20 was considered small, 0.50 medium, and 0.80 large. The CIs for the effect sizes were obtained by bias-corrected bootstrapping (5000 replications). Correlations among the variables were tested and adjusted for BMI and age.

The sample size of the RCT (IV) was calculated, based on the primary outcome measure: expected weight change with an SD of 3.6 (Rivière et al. 2001). The minimum expected weight difference was 2 kg between the intervention and control persons, and with a type-I error of 5% and power of 80%, each group calculated was required to have 50 persons to show statistical differences. The main findings are provided with 95% CIs. All participants assessed at the baseline and at 12 months were included in the data analysis of changes in nutrient intake and HRQoL (modified intention-to-treat). The intervention effects on weight, nutrient intakes, and HRQoL were derived from bootstrap-type analysis of covariance (ANCOVA). The rate of falls was calculated with 95% CIs during the 1-year follow-up, assuming a Poisson distribution. Poisson regression models were used to calculate the adjusted estimates of the incidence rate ratios (IRRs). The statistical analyses in all of the studies were performed, using the SPSS statistical program, version 22 (SPSS IBM, Armonk, NY, USA) and STATA (release 13.1, College Station, TX, USA).

4.5 Ethics approval

All of the participants signed an informed consent or, in case of poor capability of judgment, defined as MMSE < 20 or CDR memory item > 1, the consent was obtained from the closest proxy. All of the study protocols were approved by the Ethics Committee of Human Sciences of the University of Helsinki (III) or by the Helsinki University Central Hospital Ethics Committee (I, II, IV, and V). In addition, the study protocol in IV was also approved by the research committee of Kela.

5. RESULTS

5.1 Characteristics of the participants (I, II)

The groups of older people were very heterogeneous and differed in all of their background characteristics (Table 10). The NC participants were mainly females (91%) and were the youngest (mean age 69.2 years) and healthiest (mean CCI 0.7) of all the groups. Furthermore, they showed no mobility or cognitive limitations. None of them were malnourished, but 7% were at risk of malnutrition, according to the MNA.

The HBS participants had a high mean age (82.9 years). They showed no mobility limitation, but did have a number of chronic diseases (mean CCI 2.0). None of them were malnourished, but 9% were at risk of malnutrition, according to the MNA. Of all the groups, the lowest proportion of HBS participants used vitamin-D and calcium supplements.

The CGs had a mean age of 75.7 years, and 68% of them were females. Of the CGs, 3% already showed mobility limitations and 16% of them were at risk of malnutrition, according to the MNA. The CCIs (mean 1.2) showed that they had fairly low numbers of diseases. The largest proportion of CGs used vitamin-D and calcium supplements.

Of the participants with AD, 31% were females and 10% showed mobility limitations. They also had a number of chronic diseases (mean CCI 2.0). Of the AD participants, 80% fell in CDR classes 1—3. None of them were malnourished, but 43% were at risk of malnutrition, according to the MNA.

The PSNT participants were mostly Swedish-speaking, although ethnic Finns; 40% were home-careclients and 66% were females. They had the highest mean age (83.4 years) of all the groups and also presented with the highest number of comorbidities (mean CCI 2.9). However, they showed no mobility limitations, and their cognitive status was reasonably good (mean MMSE 26.2). Of this group, 3% were malnourished and 60% were at risk of malnutrition, according to the MNA.

The ALF participants were the second oldest (mean age 83.3 years) group; 82% were females. They showed the highest percentage of mobility limitations (59%), high numbers of comorbidities (mean CCI 2.1), and 82% fell in CDR categories 1—3. They had the highest prevalence of malnutrition (17%) and risk of malnutrition (68%), according to the MNA.

When categorized according to the MNA, the groups differed significantly in all of the characteristics shown in Table 11. Malnutrition was associated with higher age, low BMI, female sex, comorbidities, poor cognitive status, and institutionalization.

Table 10. Background characteristics of heterogeneous groups of older people.

Characteristics	NC class participants (n = 54)	HBS participants n = 68	CGs of AD participants n = 97	Home-dwelling participants with AD n = 99	PSNT participants n = 208	Residents of ALFs n = 374	p- value[1]
Age (SD)	69.2 (6)	82.9 (3.7)	75.7 (6.2)	77.4 (5.6)	83.4 (4.5)	83.3 (7.4)	p<0.001
Female (%)	91	0	68	31	66	82	p<0.001
CCI (SD)	0.7 (1.1)	2.0 (1.6)	1.2 (1.5)	2.0 (1.2)	2.9 (1.8)	2.1 (1.4)	p<0.001
Mobility bed/chair- ridden or does not go out	0	0	3	11	0	59	p<0.001
CDR, class 1–3, %	0	3	N.A.	80	N.A.	72	p<0.001
MNA class, % < 17 points 17–23.5 points > 23.5 points	 0 7 93	 0 9 91	 0 16 84	 0 43 57	 3 60 37	 17 68 14	p<0.001
Use of vitamin-D supplements, %	67	25	72	63	36	55	p<0.001
Use of calcium supplements, %	52	13	54	39	14	47	p<0.001

AD = Alzheimer's disease, SD = standard deviation, CCI = Charlson Comorbidity Index (Charlson et al. 1987), MNA= Mini Nutritional Assessment (Vellas et al. 1999). CDR = Clinical Dementia Rating (Hughes et al. 1982). NC = nutrition education and cooking class. HBS = Helsinki Businessmen Study. PSNT = Porvoo Sarcopenia and Nutrition Trial. CG = caregiver. ALF = assisted living facility. [1] Differences between the groups for categorical variables were tested with Chi^2 test or Fisher's exact test and for nonnormally distributed continuous variables with analysis of variance (ANOVA) or the Kruskal-Wallis test.

Table 11. Population characteristics according to the Mini Nutritional Assessment (MNA) (Vellas et al. 1999).

Characteristic	Malnourished* n = 72	At risk of malnutrition* n = 449	Normal nutritional status* n = 379	p-value[1]
Age, mean (SD)	85.0 (6.8)	82.4 (6.9)	78.5 (7.4)	p < 0.001
Female, %	75	73	55	p < 0.001
CCI, mean (SD)	2.5 (1.6)	2.3 (1.5)	1.7 (1.6)	p < 0.001
Place of residence, % Home ALF	 9.7 90.3	 43.2 56.8	 85.8 14.2	p < 0.001
CDR, % 0 or 0.5 = no definite dementia 1 = mild dementia 2 = moderate dementia 3 = severe dementia	 10.0 21.7 25.0 43.3	 34.7 20.8 25.7 18.8	 77.2 13.7 8.6 0.5	p < 0.001
MMSE, mean (SD)	24.3 (3.6)	24.3 (4.9)	26.2 (4.4)	p < 0.001
BMI, mean (SD)	21.5 (4.6)	26.5 (4.7)	26.4 (3.8)	p < 0.001

[1]Differences between the groups for categorical variables were tested with the Chi^2 test or Fisher's exact test and for nonnormally distributed continuous variables with the Kruskal-Wallis test, SD = standard deviation, CCI = Charlson Comorbidity Index (Charlson et al. 1987), CDR = Clinical Dementia Rating scale (Hughes et al. 1982), MMSE = Mini-Mental State Examination (Folstein et al.1975). BMI = body mass index, ALF = assisted living facility. *According to Mini Nutritional Assessment

5.2 Energy, nutrient, and fiber intakes of the participants (I, II)

The heterogeneous groups of older people differed significantly in nutrient intakes (Table 12). Although the mean intakes of most nutrients were according to recommendations, the ranges of nutrient intakes were very large. Low dietary intakes of energy, protein, and micronutrients were observed in all the groups of older people, including the healthiest. Thus, within each group there were individuals who received inadequate amounts of various nutrients, and some even had intake values under the LIs of micronutrients.

The NC group generally showed the highest protein and micronutrient intakes of all the groups and the ALF group the lowest intakes in most micronutrients. Protein intakes (g/kg BW) between the groups did not differ. The total protein intake was lowest in AD and ALF females. Only the NC group showed the mean protein intake according to the recommendations (Nordic Nutrition Recommendations 2014).

The AD women (1313 kcal/d) and male CGs (1575 kcal/d) had the lowest energy intakes. They were the only groups that had lower energy intake than the estimated consumption range (Table 12). The ALF group had relatively favorable energy intake (females /males 1653/1870 kcal/d). Furthermore, the ALF group had the highest carbohydrate (222.4 g/d) intake, but the carbohydrates were of low quality, and thus the ALF group had the highest sugar and the lowest dietary fiber intakes.

A high proportion (86%) of all groups of older people received more than the recommended amount of saturated fatty acids (SFAs) in their diets (SFA < 10 E %). The ALF residents received the least total fat, and their PUFA and vitamin-E intakes were very low. On the other hand, the PSNT participants received significantly higher amounts of PUFAs than the other groups. The AD and CG participants also had the lowest mean intakes of vitamin C and thiamine and the AD females low vitamin-E intakes.

The dietary intakes of energy, protein, vitamins D, E, folate, and calcium are presented for each group of older people in Table 12. A more detailed comprehensive table of nutrient intakes is in the original article (I, Table 2).

Table 12. Dietary intakes of various heterogeneous groups of older people.

	NC (n = 54)	HBS (n = 68)	CG (n = 97)	AD (n = 99)	PSNT (n = 208)	ALF (n = 374)	p- value[1]	RI female/male AR female/male*
Energy, kcal estimation[2] (BE ± 20%) females males	 1759 (1689–2200) 2112 (1689—2639)	 N.A. 1856 (1561–2439)	 1805 (1362–2128) 1775 (1596–2494)	 1869 (1377–2152) 1928 (1599–2450)	 1797 (1348–2106) 1864 (1649–2577)	 1705 (1282–2003) 1759 (1518–2372)	 p < 0.001 p = 0.002	
Mean daily dietary intake								
Energy, MJ (SD) females males	 7.1 (1.8) 7.8 (2.4)	 N.A. 7.1 (1.7)	 6.5 (1.7) 6.6 (1.9)	 5.5 (1.4) 7.9 (1.7)	 6.7 (1.8) 7.5 (2.2)	 6.9 (1.7) 7.8 (2.3)	 p < 0.001 p = 0.005	6.6/8.7
Energy, kcal (SD) females males	 1703 (425) 1852 (590)	 N.A. 1704 (413)	 1551 (414) 1575 (448)	 1313 (340) 1897 (416)	 1608 (420) 1798 (529)	 1653 (409) 1870 (545)	 p < 0.001 p = 0.005	1570/2070[2]
Protein, total, g (SD) females males g/kg BW/d	 82.3 (22.7) 87.3 (26.1) 1.2 (0.4)	 N.A. 77.1 (27.4) 1.0 (0.4)	 67.5 (18.7) 69.9 (21.5) 1.0 (0.3)	 57.8 (19.6) 80.4 (22.5) 1.0 (0.3)	 67.7 (20) 75.6 (25.1) 1.0 (0.4)	 60.2 (17.8) 68.2 (21.1) 1.0 (0.3)	 p < 0.001 p = 0.086 p = 0.094	 1.2–1.4
Total vitamin D, µg (SD) Supplemental	27.0 (18.9) 16.2 (18.3)	15.0 (13.3) 3.9 (7.2)	17.8 (9.6) 10.1 (9.7)	19.4 (11.5) 7.3 (7.1)	18.0 (11.7) 7.1 (10)	17.0 (10.5) 10.1 (8.8)	p < 0.001 p < 0.001	20 15*
Vitamin E, mg (SD) females males	 13.2 (6.2) 11.2 (4.8)	 N.A. 10.1 (5)	 9.7 (4.3) 8.1 (3.6)	 6.4 (2.6) 10.9 (4.3)	 8.7 (3.5) 9.3 (3.6)	 6.0 (2.2) 6.8 (2.7)	 p < 0.001 p < 0.001	 8/10 5/6*
Folate, µg (SD)	286 (70)	256 (95)	225 (70)	233 (74)	263 (128)	229 (121)	p < 0.001	300 200*
Calcium, total mg (SD) Supplemental	1387 (531) 381 (457)	1000 (446) 55 (155)	1275 (523) 387 (414)	1224 (487) 260 (357)	1052 (450) 94 (255)	1529 (594) 399 (438)	p < 0.001 p <0.001	800 500*

NC = older people who took part in nutrition education and cooking classes, HBS = older men from Helsinki Businessmen Study, CG = spousal caregivers of people with Alzheimer´s disease, AD = home-dwelling people with Alzheimer´s disease, PSNT = Porvoo Sarcopenia and Nutrition Trial participants, ALF residents = residents of assisted living facilities. MJ = megajoule, SD = standard deviation, RI = recommended intake, AR = average requiremen (Nordic Nutrition Recommendations 2014). [1]Differences between nonnormally distributed continuous variables were tested with the Kruskal-Wallis test. [2]National Nutrition Council recommendation.[2] Energy consumption estimation is calculated according to the WHO's formula. SD = standard deviation. BEE = basal energy expenditure. BW = body weight. N.A. = not applicable.

The groups of older people also differed in the proportion of energy nutrients in their diets. The E% of protein declined linearly from those in the best nutritional status (NC) towards those with the poorest nutritional status (ALF). The ALF group received 14.6 E% from protein, whereas the corresponding figure in the NC group was 19.5 E% (Table 13). In contrast, the E% obtained from carbohydrate was lowest in the NC group (40 E%) and highest in the ALF group (53 E%). The proportion of E% in fat was also highest in the NC group (38.5 E %) and lowest in the ALF group (31 E%). In general, the proportion of energy nutrients was within the recommendations in almost all the groups of older people. The ALF group obtained somewhat lower E% from protein than recommended, and the NC group received a lower than recommended E% of carbohydrate.

Table 13. Proportions of E% of energy nutrients of heterogeneous groups of older people.

Energy nutrients	Recommendation[1]	NC	HBS	CG	AD	PSNT	ALF	p-value[2]
Protein, E%	15–20 E%[3]	19.5	18.1	17.6	17.1	16.9	14.6	p < 0.001
Carbohydrate, E%	45–60 E%	40.0	44.8	45.9	46.6	44.8	52.7	p < 0.001
Fat, E%	25–40 E%	38.5	34.1	34.6	34.4	35.0	31.1	p < 0.001

[1]Nordic Nutrition Recommendation (Nordic Nutrition Recommendations 2014), [1]Differences between the groups were tested with the Chi^2 –test. [3]For people ≥ 65 years of age (Nordic Nutrition Recommendations 2014). NC = older people who took part in nutrition education and cooking classes, HBS = older men from Helsinki Businessmen Study, CG = spousal caregivers of people with Alzheimer´s disease, AD = home-dwelling people with Alzheimer´s disease, PSNT = Porvoo Sarcopenia and Nutrition Trial participants, ALF residents = residents of assisted living facilities.

Of all the groups, the ALF had the lowest protein and micronutrient density in most of the micronutrients selected (vitamins A, D, E, folate, iron, and zinc) (Table 14). The CG and AD groups had the lowest nutrient density in thiamine and HBS participants in calcium, although the mean calcium intake was adequate (table 14).

Table 14. Nutrient densities of protein and selected micronutrients (per 7 MJ) in heterogeneous older population groups.*

Dietary nutrients	NC	HBS	CG	AD	PSNT	ALF	p-value[1]
Protein, g	81.4	75.5	73.7	71.4	70.7	61.1	p < 0.001
Protein g/ kg BW/d	1.14	0.98	1.06	0.97	1.03	0.99	p < 0.001
Vitamin A, µg	1400	823	1225	1094	996	744	p < 0.001
Vitamin D, µg	10.5	10.4	10.1	10	10.8	6.8	p < 0.001
Vitamin E	12.5	9.5	9.7	9.1	8.7	6.1	p < 0.001
Vitamin C	111	102	83	79	104	101	p < 0.001
Folate	285	251	243	229	261	228	p < 0.001
Thiamin	1.2	1.2	1.1	1.1	1.3	1.2	p < 0.001
Calcium	993	929	948	945	958	1119	p < 0.001
Iron	10.3	9.8	10.1	9.7	11	8.6	p < 0.001
Zinc	11.5	10.8	11.1	10.9	10.7	9.5	p < 0.001

* 7 MJ was chosen because it was the mean energy intake level of the entire sample. [1]Differences between the groups were tested with the Chi^2 –test- NC = older people who took part in nutrition education and cooking classes, HBS = older men from Helsinki Businessmen Study, CG = spousal caregivers of people with Alzheimer´s disease, AD = home-dwelling people with Alzheimer´s disease, PSNT = Porvoo Sarcopenia and Nutrition Trial participants, ALF residents = residents of assisted living facilities. BW = body weight. The lowest nutrient density of each nutrient of the groups is highlighted in the table.

5.2.1 Nutrient intakes according to the Mini Nutritional Assessment classes

Better MNA status was associated with higher intakes of energy, total protein, and micronutrients. The better nutritional status according to MNA was associated with higher energy in females, higher fat, total protein and most micronutrient intakes in both sexes. The dietary intakes were lowest in the malnourished group in energy, total protein, fat, and all other micronutrients, except for total calcium and vitamin D when supplemental use was included. However, the total carbohydrate ($p = 0.014$), and total calcium ($p = 0.037$) intakes showed a contrasting trend, in which the malnourished had the highest intakes of these nutrients and those with normal nutritional status the lowest. The energy, protein, and micronutrient intakes are presented according to the MNA classes in Table 15.

Table 15. Energy and nutrient intakes of older people divided according to MNA classes.

Dietary energy and nutrient intakes	Malnutrition* n = 72	At risk of malnutrition* n = 449	Normal nutritional status* n = 379	p-value[1]
Energy total kcal, mean (SD) females males	1592 (421) 1553 (358) 1708 (569)	1661 (454) 1598 (427) 1829 (482)	1715 (446) 1665 (412) 1776 (479)	0.16 0.031 0.080
Protein, total g, mean (SD)	55.8 (18.0)	65.6 (21.4)	73.3 (22.2)	< 0.001
Carbohydrates total g, mean (SD)	209.0 (66.3)	205.0 (63.9)	195.1 (59.6)	0.014
Fat total g, mean (SD)	56.4 (19.2)	60.4 (22.1)	66.6 (24.6)	< 0.001
Vitamin C mg, mean (SD)	91 (52)	95 (58)	103 (65)	0.044
Folate µg, mean (SD)	195 (68)	232 (104)	264 (120)	< 0.001
Thiamine mg, mean (SD)	1.1 (0.4)	1.2 (0.4)	1.2 (0.4)	0.031
Vitamin E mg, mean (SD)	5.9 (2.6)	7.2 (3.3)	9.7 (4.6)	< 0.001
Vitamin A µg, mean (SD)	583 (518)	841 (1212)	1111 (1462)	< 0.001
Vitamin D µg, mean (SD)**	18.4 (9.8)	17.2 (11.4)	18.9 (12.8)	0.19
Calcium mg, mean (SD)**	1391 (616)	1344 (590)	1253 (528)	0.010
Iron mg, mean (SD)	8.1 (4.0)	9.2 (3.3)	10.3 (3.6)	< 0.001
Magnesium mg, mean (SD)	265 (92)	306 (92)	331 (93)	< 0.001
Zinc mg, mean (SD)	8.7 (2.9)	10.0 (3.3)	10.9 (3.1)	< 0.001
Selenium µg, mean (SD)	52 (19)	61 (23)	65 (24)	< 0.001

* Measured with Mini Nutritional Assessment (MNA) (Vellas et al. 1999). ** Includes supplemental intake, SD = standard deviation, SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids. BW = body weight. [1]Statistical significance for hypotheses of linearity was evaluated with analysis of variance (ANOVA).

5.2.2 Dietary intakes in heterogeneous groups of older people compared with RIs and ARs

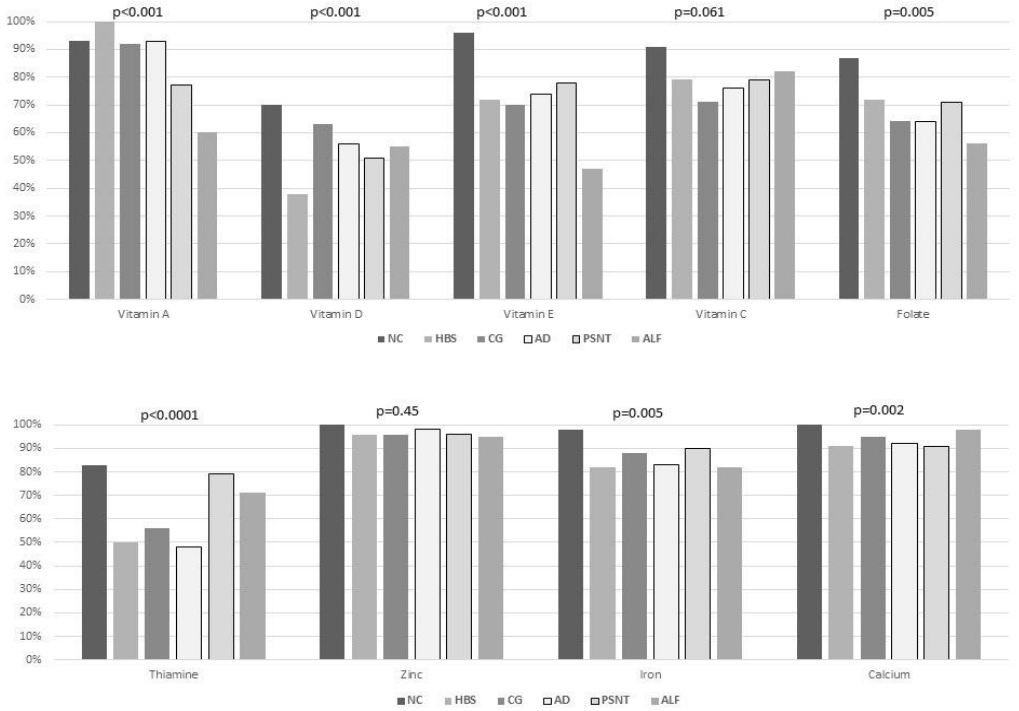
When the dietary intake was compared with the RI, only 45% of the entire sample received the RIs of energy. The HBS showed the lowest proportion of participants who received the RIs of energy. The protein intake was below the RI in 77% of the entire sample. There were no differences in this respect between the groups in energy or protein intakes (g/kg BW/d). When the protein intakes were compared between the MNA groups, 77% of the malnourished, 79% of those at risk of malnutrition, and 74% of those with normal nutritional status had protein intakes below the RI. The proportion of participants with intakes below the RI of protein did not differ between the MNA groups (p = 0.20).

As many as 89% of the entire sample had fiber intakes below the RIs. Of the ALF residents, 85% received less PUFA than recommended, whereas all PSNT participants received the RIs of PUFAs. The proportions of people receiving the RIs of vitamins A, D,

E, C, folic acid, thiamine, zinc, iron, calcium, PUFAs, and fiber differed significantly among the heterogeneous groups. The NC group had the largest proportion of people receiving RIs of energy, fiber, and micronutrients. The lowest proportions of individuals receiving the RIs of vitamins A, E, iron, PUFA, and fiber were observed in the ALF group.

The ARs for zinc and calcium were met by 96% and 95% of the participants, respectively (Figure 4). Throughout the sample, a large proportion of participants had insufficient intakes of vitamins A (24%), D (46%), E (36%), C (20%), folate (35%), thiamine (32%), and iron (14%). Of the HBS and PSNT participants, 62% and 49% had insufficient intakes of vitamin D, respectively, even when taking into account supplemental vitamin-D use. The ALF group had the largest proportion of insufficient vitamin-A (40%), vitamin-E (53%) and folate intakes (42%). The CG (29%) and AD (24%) groups had the largest proportion of individuals receiving less than the ARs of vitamin C. Of the AD and the HBS groups, 52% and 50% received insufficient amounts of thiamine, respectively.

Figure 4. Proportion of heterogeneous groups of older people receiving average requirements (ARs) of selected micronutrients.



NC = older people who took part in nutrition education and cooking classes, HBS = older men from Helsinki Businessmen Study, CG = spousal caregivers of people with Alzheimer´s disease, AD = home-dwelling people with Alzheimer´s disease, PSNT = Porvoo Sarcopenia and Nutrition Trial participants, ALF residents = residents of assisted living facilities.

5.2.3 Low intakes

Intake values under the LI were most often observed in vitamins A, D, E, and iron. Of the entire sample, 24% of the participants' intake was below the LIs of vitamin A (females < 400 µg, males < 500 µg) (Nordic Nutrition Recommendations 2014). Intake values below the LIs in vitamin A were most frequently observed in the ALF residents (32%), HBS group (34%), and in the PSNT participants (25%) ($p < 0.001$). Intakes below the LIs for vitamin D were observed in 13% of the entire sample, when both dietary and supplemental use was taken into account. Intakes below the LIs in vitamin D were most frequently observed in the HBS group, ALF residents, and PSNT participants, of whom 25%, 16%, and 12% had intakes under the LIs, respectively. Intakes below the LIs of vitamin E were observed in 6% of all participants, of whom the ALF (9%) and HBS (7%) showed the most frequent intakes below the LI. Iron intakes below the LIs were observed in 6% of all the participants, of whom the HBS (9%), AD (8%), and ALF (8%) groups showed the highest proportions of people whose intakes were below the LIs.

5.2.4 Upper intake level

Intakes exceeding the UL were observed, particularly in calcium and vitamin A. High calcium intake was associated with supplemental use. Only one participant had calcium intake above the UL without consuming supplements. The UL for calcium was exceeded by 3% of all the participants, of whom the ALF (6%) and NC (6%) groups had the highest proportions of people exceeding the ULs. The ULs for vitamin A were exceeded by 6% of the entire sample. 1. Intake values above the ULs were most frequently observed in the NC (15%), CG (10%), PSNT (9%), and AD (6%) groups. In vitamin A, only the dietary intake was accounted for.

5.3 Sensitivity and specificity of the Mini Nutritional Assessment (II)

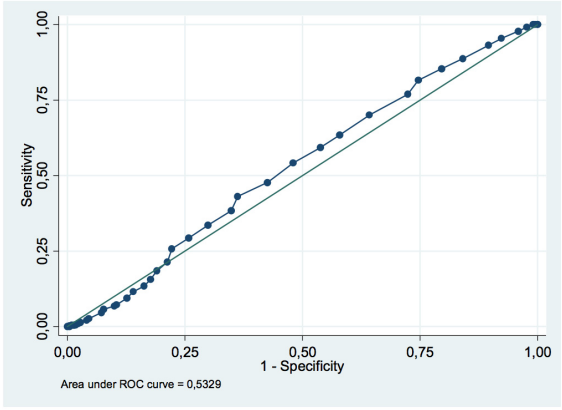
The sensitivity and specificity of the MNA in detecting protein intake of 1.0 g/kg BW/d were 0.57 and 0.52, respectively and for protein intake of 1.2 g/kg BW/d 0.82 and 0.25, respectively (Table 16). The sensitivity and specificity for energy intake according to the MNA (1570 kcal for females and 2070 kcal for males) were 0.32 and 0.75, respectively. The area under the curve (AUC) values of the MNA were low for both recommended protein and energy intakes, even when the best cut-off points with the highest accuracy were used. The respective ROC curves are illustrated in Figure 5.

Table 16. Sensitivity and specificity rates, positive likelihood ratios (LR+) of MNA compared with protein intakes of 1.0 g/kg BW and 1.2 g/kg BW and energy intakes (1570 kcal for females and 2070 kcal for males).

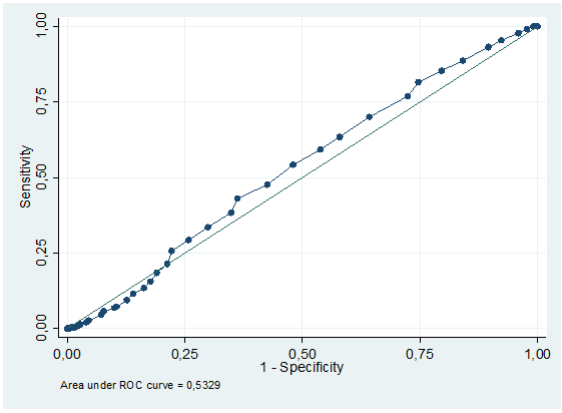
Measurements	AUC	MNA cut-off* point	Sensitivity	Specificity	LR+
Protein 1.0 g/kg BW	0.53	< 23	0.57	0.52	1.17
Protein 1.2 g/kg BW	0.53	< 26	0.82	0.25	1.09
Energy	0.52	< 21	0.32	0.75	1.28

BW = body weight. AUC = area under the curve.
*Best cutoff value as the value with the highest accuracy that maximizes the Youden's index

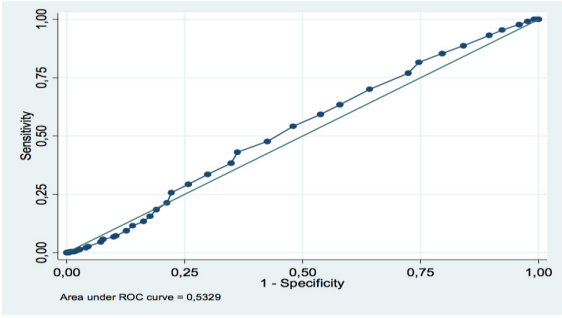
Figure 5. ROC curve of sensitivity and specificity rates of MNA compared with protein intakes of 1.0 g/kg BW (Panel A), 1.2 g/kg BW (Panel B), and energy intakes (1570 kcal for females and 2070 kcal for males) (Panel C).



Panel A



Panel B



Panel C

5.4 Effects of nutritional intervention (III—V)

5.4.1 Nutrition education and cooking classes (III)

Of the NC class participants, 7% were at risk of malnutrition and none were malnourished, according to the MNA. Diet quality measured by the IDQ was poor in 28% of the study subjects at baseline (Mäkelä et al. 2012). The participants had lower than the RIs of folate (60%), iron (48%), vitamin E (22%), vitamin C (21%), and fiber (69%) at baseline. After 4 months of follow-up, the IDQ (p = 0.013), vitamin-C (p = 0.019) and fiber intakes (p = 0.027) improved (Table 17). The change in intakes of other nutrients did not reach statistical significance. The PWB score also improved (p = 0.02).

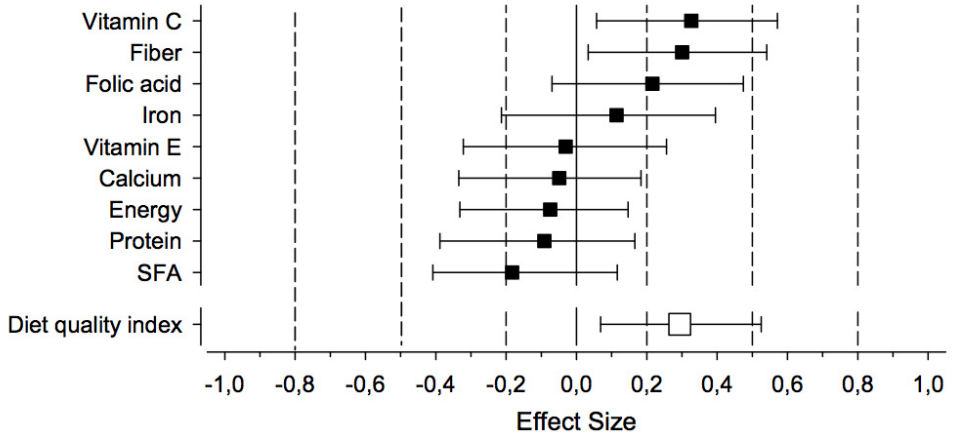
Table 17. Index of Diet Quality, energy, and specific nutrient intake at baseline and after a 4-month follow-up period.

Dietary intakes and diet quality n = 54	Baseline mean (SD)	Change after 4 months Mean (95% CI)	p-value
IDQ[1]	10.6 (1.9)	+0.5 (0.1 to 1.0)	0.013
Energy (kcal)	1711 (442)	-32 (-124 to 64)	0.50
Protein (g)	82 (23.1)	-2.2 (-8.5 to 3.6)	0.47
Vitamin E (mg)	12.8 (6.1)	-0.2 (-1.7 to 1.6)	0.83
Vitamin C (mg)	112.6 (43.8)	+19.2 (4.4 to 37.5)	0.019
Folic acid (µg)	287 (70)	+18.6 (-4.7 to 44.2)	0.14
Calcium (mg)	1007 (319)	-16.8 (-99.4 to 69.4)	0.69
Iron (mg)	10.3 (2.2)	+0.3 (-0.5 to 1.2)	0.48
SFA[2] (g)	27.6 (12.9)	-1.9 (-4.9 to 0.7)	0.18
Fiber (g)	22.9 (6.3)	+2.2 (0.3 to 4.2)	0.027

[1]IDQ = Index of Diet Quality. [2]SFA = saturated fatty acid. SD = standard deviation. CI = confidence interval.

The effect size changes were small and at best near medium in vitamin C, fiber, folate intakes, and IDQ (Figure 6).

Figure 6. Effect sizes of changes in Index of Diet Quality (IDQ) , vitamin C, fiber, folic acid, iron, vitamin E, calcium, energy, protein, and saturated fatty acid (SFA) intakes.



Overall, 98.2% of the participants gave the course an overall rating of very good or good. The nutrition education was rated by 98.3% of the participants as very good or good, and the participants reported that they learned new things. Of the participants, 94% were satisfied with the personal feedback given to them by the nutritionist on their diet and diet quality. All participants stated that they would recommend the course to their friends and acquaintances.

5.4.2 Nutritional counseling of home-dwelling older people with Alzheimer's disease (IV, V)

In all, 78 home-dwelling older people with AD completed the 1-year NuAD intervention study. At the baseline, none of the participants were malnourished, but 40% were at risk of malnutrition according to the MNA. No differences in energy intake between the intervention and control groups were observed at baseline (Table 18). The mean energy intake for men with AD was 1901 kcal/d and for women with AD, 1281 kcal/d. The nutrient intakes at baseline varied between the intervention and control groups (Article IV). Of the participants, 55% had a protein intake of less than 1.0 g/kg BW and 77% less than 1.2 g/kg BW/d no differences between the intervention and control groups were observed at the baseline. The mean CCI was 2.0, and the mean number of medications was 5.6.

Table 18. Baseline characteristics of home-dwelling Alzheimer's disease participants in the intervention and control groups who completed the intervention.

Characteristic	Intervention group (n = 40)	Control group (n = 38)	p-value
Age, years (SD)	78.2 (5.5)	76.8 (5.9)	0.29
Females, %	47	53	0.81
CCI, mean (SD)	2.1 (1.3)	1.8 (1.1)	0.39
Number of medications, mean (SD)	5.5 (2.7)	5.5 (2.3)	0.92
MMSE, mean (SD)	18.8 (6.4)	20.2 (4.7)	0.27
CDR, % 0.5–1 points 2–3 points	 68 45	 55 34	 0.32
MNA class, % < 17 points 17–23.5 points > 23.5 points	 0 43 57	 0 37 63	 0.65
Mean weight, kg (SD)	75.4 (14.4)	74.0 (9.3)	0.63
Mean BMI, kg/m^2 (SD)	26.3 (3.6)	25.9 (2.9)	0.61
15D HRQoL (SD)	0.76 (0.11)	0.77 (0.14)	0.99

Groups were compared with paired samples t-test or Mann-Whitney U test for continuous, and Chi^2 or Fisher's exact test for categorical variables. SD = standard deviation; MMSE = Mini-Mental State Examination; CDR = Clinical Dementia Rating scale (0–0.5 possible or mild dementia, 2–3 moderate or severe dementia) (Hughes et al. 1982); MNA = Mini Nutritional Assessment (>23.5 good nutritional status, 17–23.5 risk for malnutrition, <17 malnourished) (Vellas et al. 1999); BMI = body mass index, HRQoL = Health-Related Quality of Life with 15D (Sintonen 2001); CCI = Charlson Comorbidity Index (Charlson et al. 1987).

During the intervention, 70% of the AD participants in the intervention group received ONSs containing 20 g of protein per day for 4-12 weeks, 70% participated in the group meeting once and one couple twice during the intervention. The mean protein and calcium intakes increased in the intervention group and decreased in the control group (Table 19, Figure 7). For other nutrients (e.g. vitamin C, vitamin E, and folic acid), there were similar trends, but they did not reach statistical significance.

Figure 7. Protein intake in the control and intervention groups at baseline and at the end of the trial.

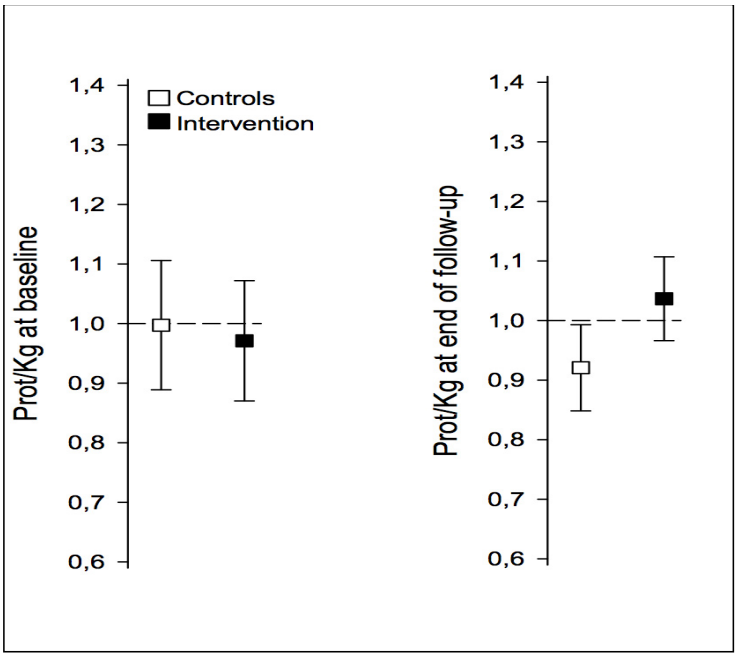


Table 19. Mean dietary intake of people with Alzheimer's disease at baseline and mean changes in nutrient intakes from baseline to 12 months in the intervention and control groups.

	Baseline		Change after 12 months		p-value*
Mean daily dietary intake	Intervention (n = 40)	Controls (n = 38)	Intervention (95% CI)	Controls (95% CI)	
Total protein, g (SD)	72.1 (24.5)	73.6 (25.1)	3.1 (-4.1 to 10.2)	-2.5 (-7.7 to 2.6)	0.11
Protein g/kg BW (SD)	0.97 (0.32)	1.00 (0.33)	0.05 (-0.06 to 0.15)	-0.06 (-0.12 to 0.02)	0.03
Vitamin C, mg (SD)	75.2 (50.7)	78.7 (33.3)	12.0 (0.7 to 23.2)	2.0 (-12.1 to 16.1)	0.25
Folate, µg (SD)	226.4 (75.7)	239.6 (76.9)	6.9 (-11.2 to 25.0)	-9.2 (-23.4 to 5.1)	0.13
Vitamin E, mg (SD)	8.7 (4.6)	10.4 (4.7)	0.3 (-0.7 to 1.4)	-0.9 (-1.8 to 0.1)	0.28
Calcium, mg (SD)	956 (416)	954 (400)	85 (-24 to 194)	-17 (-98 to 65)	0.03

*p-value for changes between the groups from baseline to 12 months. The treatment effects on intake of nutrients were derived from bootstrap-type analysis of covariance (ANCOVA) adjusted to baseline value, age, sex, MMSE, and BMI. SD = standard deviation. CI = confidence interval.

The total score in the 15D HRQoL increased in the intervention group and decreased in the control group (Table 19). The dimensions of the 15D that showed significant differences between the intervention and control groups included mental functioning reflecting cognition, breathing, usual activities reflecting daily physical functioning, and depression (Table 20).

Table 20. Dimensions of the Health-Related Quality of Life 15D instrument in the intervention and control groups in the NuAD study.

Dimension of 15D Health-Related Quality of Life	Control group (n = 38)	Intervention group (n = 40)	p - value
Mental functioning (cognition)	-0.11 (95% CI -0.17 to -0.049)	0.012 (95% CI -0.044 to 0.069)	p = 0.006
Breathing	-0.035 (95% CI -0.087 to 0.016)	0.036 (95% CI -0.014 to 0.086)	p = 0.048
Usual activities (physical functioning)	-0.086 (95% CI -0.153 to -0.019)	-0.009 (95% CI -0.074 to 0.056)	p = 0.046
Depression	-0.030 (95% CI -0.079 to 0.020)	0.037 (95% CI -0.010 to 0.084)	p = 0.045
Total score	0.006 (95% CI -0.016 to 0.028)	-0.036 (95% CI -0.059 to 0.013)	p = 0.007

P-value for changes between the groups from baseline to 12 months. The treatment effects on intake of nutrients were derived from bootstrap-type analyses of covariance (ANCOVA) adjusted to baseline value, age, sex, MMSE, and BMI. CI = confidence interval.

In the intervention group, the AD participants experienced 31 falls and in the control group 63 falls. The fall rate during the follow-up was 0.55 falls per person per year (95% CI: 0.34-0.83) in the intervention group and 1.39 falls per person per year (95% CI: 1.04—1.82) in the control group. In the control group, the IRR was 3.74 [(95% CI: 2.16—6.46) $p < 0.001$, adjusted for age, sex, and MMSE], compared with the intervention group.

6. DISCUSSION

6.1 Energy, nutrient, and fiber intakes of the participants (I, II)

While malnutrition and its risks were consistently associated with mobility, cognition, and comorbidities, the energy, protein, and micronutrient intakes revealed a more detailed picture of the nutritional risks among older people. In all of the heterogeneous groups of older people, even among the healthiest, there were large proportions of participants who received less than the RIs of energy, protein, and micronutrients. Protein intakes less than those recommended were observed in 77% of all participants. Insufficient intakes compared with the AR were most often observed in vitamins A, D, E, C, folate, and thiamine. The MNA status was consistently associated with diet quality, energy, total protein, and micronutrient intakes. However, in people with normal nutritional status according to the MNA, large proportions also had low energy and protein intakes and insufficient micronutrient intakes.

Age, female sex, poor cognition, comorbidities, institutionalization, and low BMI were associated with malnutrition. These observations confirm findings from previous studies (Gillette-Guyonnet et al. 2000, Sharkey et al. 2002 Guigoz 2006, Shatenstein et al. 2007, Vikstedt et al. 2011). Surprisingly, the protein (g/kg BW) intakes were not associated with malnutrition. Although the energy intakes of the malnourished participants or those at risk of malnutrition were not much lower than in people with normal nutritional status, their micronutrient intakes were lower, suggesting low nutrient density of the foods consumed in the malnourished group. The total carbohydrate and sugar consumption were highest in the malnutrition group and lowest in people in the normal nutrition status group. Fiber intake showed a contrasting trend and was lowest in the malnutrition group and increased towards the normal nutritional status. We thus assumed that the malnutrition groups consumed high amounts of low-quality carbohydrates. High consumption of low-quality carbohydrates may cause protein and micronutrient dilution (Charlton et al. 2005). Poor diet quality seemed to be a major problem throughout the sample.

While those with the poorest functioning (ALF) had relatively favorable energy intake, their nutrient densities of the foods consumed were the lowest, and thus they received low amounts of various essential nutrients. The ALF residents' diets had more SFAs and less PUFAs than recommended. Furthermore, they received more energy from low-quality processed carbohydrates with very little fiber, and thus their dietary quality was low. In fact, their nutrient density was the worst in protein and in most micronutrients of all the groups. This was disappointing, since nutrition recommendations should be applied when planning the residents' diets. However, the residents' personal preferences may also have influenced their nutrient intakes. In a small study done in the UK, SHRs had considerable lower energy levels than the ALF residents did, and thus their mean protein and micronutrient intakes were even lower (Leslie et al. 2006).

The male CGs and the AD females had poor intake of energy, protein, and several micronutrients, and thus they seemed to be at high risk of developing malnutrition. People with AD are a known risk group for malnutrition (Gillette-Guyonnet et al. 2000, Shatenstein et al. 2007). A high percentage of HBS participants also had insufficient intakes of various micronutrients. Thus, independently living older men may be another group at risk of developing malnutrition. Although the HBS group had a low prevalence of risk of malnutrition (9%) according to the MNA, they had the highest proportion of participants not receiving RIs of energy, vitamin D, folate, zinc, and calcium.

A large proportion of the PSNT group belonged mainly to a Swedish-speaking minority who are known to have a significantly longer life expectancy than the general population in Finland (Hyyppä and Mäki 2001). According to the MNA, 60% of these people were at risk of malnutrition. Their mean age was the highest; they suffered from the highest number of comorbidities, and used large numbers of drugs that decreased their MNA score. They had the highest mean intakes of PUFAs and thiamine, suggesting that they had eating habits somewhat different from those of the other groups, although they also presented with insufficient intakes of many micronutrients. The NC group was the youngest and healthiest, and they had higher dietary protein and micronutrient intakes than the other groups.

Detailed food record data among older people are still scarce. Published studies have provided detailed information on the nutrient intakes of older people in various settings and at different stages of functioning (de Groot et al. 1999, Sharkey et al. 2002, Volkert et al. 2004, Leslie et al. 2006, Shatenstein et al. 2007). In a cross-sectional study done in Germany on home-dwelling older people, a high percentage of the participants had insufficient intakes of vitamin D and folate, although their median energy and protein intakes were relatively high (Volkert et al. 2004). In a study by Xu et al. (2014) among independent older people in China, low protein intakes were observed in association with adequate mean energy intakes. However, all of these studies focused on single population groups of older people and did not compare nutrient intakes in heterogeneous older population samples. Some studies allowed comparison with our findings. In the SENECA study, home-dwelling older people from eight European countries (47% of women and 24% of men) received inadequate amounts of at least one of the micronutrients (iron, thiamine, pyridoxine, or riboflavin) (de Groot et al. 1999). In a study conducted by Sharkey et al. (2002), 27% of homebound older people had inadequate intakes of six or more micronutrients. In our study, 75% of the participants had insufficient intakes of at least one and 52% of two or more micronutrients.

The men in all the heterogeneous groups had somewhat lower reported mean energy intakes than recommended (VRN 2005). The mean energy intakes in females were within the recommendations, except for the AD females who had very low energy intakes. In males, the energy intakes did not differ between the groups. The energy intakes were in general within the ranges of TEE calculations (BEE ±20% x 1.3) in all other groups, except for the AD females and CG males, both of whom had reported energy intakes that were

somewhat lower than the lower range of energy expenditure calculations (WHO 1985, Nordic Nutrition Recommendations 2014). Puranen et al. (2014) observed that male CGs often had insufficient cooking skills and lack of knowledge of nutrition; thus they and their AD spouses may have been at risk of malnutrition. Male CGs may need assistance to care for the nutritional needs of their AD spouses and of their own nutritional needs (Puranen et al. 2014). AD males, on the other hand, had the highest mean energy intake of all the groups.

The optimal protein intake for older people has been widely debated in recent years. There is a widely accepted consensus among gerontologists, however, that the physiological need for protein increases as a person ages (Bauer et al. 2013). In previous studies, low mean protein intakes have been reported, especially in the frailest and most compromised of older people, such as hip fracture and dementia ward patients, very old home-careclients, recipients of home-delivered meal services, and SHRs (Sharkey et al. 2002, Suominen et al. 2004, Lesley et al. 2006, Silver et al. 2008, Johnson and Begum 2008, Calvani et al. 2014). Furthermore, home-dwelling AD patients have had lower protein and micronutrient intakes than have cognitively intact controls (Shatenstein et al. 2007). However, in most of the studies the amount of protein was expressed as total intake in grams, which prevents direct comparison. In the present study, 77% of all the participants received less than the RIs for protein (Nordic Nutrition Recommendations 2014). More than half failed to attain levels of 1.0 g/kg BW/d which is considered the minimum requirement of protein for healthy older people as recommended by a scientific expert group (Bauer et al. 2013). Furthermore, more than one third of the participants failed to receive even the very conservative recommendation of 0.83 g/kg BW/d given by EFSA (2012).

The distribution of energy nutrients showed that the frailest older people (the ALF group) obtained less than the recommended E% from protein. Furthermore, the E% obtained from protein declined linearly from those with the best nutritional status (NC) towards those with the poorest nutritional status (ALF). In the planning of diets of older people in institutionalized settings, the protein E% objective of the diet is 18 E%; thus the objective was not reached by the ALF residents, since they only received 14.6 E% from protein (Nordic Nutrition Recommendations 2014). Surprisingly, even in those participants with normal nutritional status, 74% had lower than the recommended protein intake. Low protein intake is associated with increased risk of frailty (Beasley et al. 2010). Sufficient protein intake in older people is crucial to the prevention of sarcopenia, maintenance of muscle mass and functional ability (Bauer et al. 2013). Clearly, there is a need to promote protein intake, not only for frail older people with comorbidities, but also for the still functional and healthy older population.

Physiological conditions, such as inflammation, may increase protein and micronutrient needs (Bauer et al. 2013). Insufficient intakes of micronutrients were most often observed in vitamins D, E, and folate, including in people with normal nutritional status. About one fifth of the entire sample had insufficient vitamin C intakes. Calcium intake was adequate

in all the MNA groups. The calcium intake recorded was highest in the malnutrition group and decreased towards the normal nutritional status. This was partly because we also recorded supplemental calcium use. The frequency and amount of calcium supplements used were highest in the malnutrition group. Supplemental calcium use was very similar in the malnutrition risk and normal nutritional status groups.

The most problematic were the participants in each group whose energy intake was very low. Low energy intake combined with low nutrient density result in poor protein and micronutrient intakes. However, when nutrient density is very low, even adequate energy intakes cannot guarantee adequate nutrient intakes (de Groot et al. 1999, Volkert et al. 2004)

Even values below the LIs of micronutrients were observed among some of the participants. Values below the LIs were most frequently observed in the fat-soluble vitamins A, D, E, and iron. The groups of older people who most frequently had intakes below the LIs were the ALF, HBS, PSNT, and AD groups. Since values below the LI are cut-off point for causing clinical nutrient deficiency symptoms for nearly all people, this is a matter for concern (Nordic Nutrition Recommendations 2014). Especially low vitamin D intakes may cause adverse health effects (Bischoff-Ferrari et al. 2009). Of home-dwelling older people, older men (HBS) seem especially to be a risk group for low micronutrient intakes.

Intakes above the UL were observed in calcium and vitamin A. Exceeding the ULs for calcium was associated with supplemental calcium use. For vitamin A, only the dietary vitamin was accounted for. Vitamin A is a fat-soluble vitamin and intake for only 1—3 days may not represent the average intake of an individual over a longer period of time. It seems, however, that at the group level a proportion of older individuals may be at risk of receiving too much vitamin A, especially if supplements such as commonly used cod liver oil-derived products are consumed in addition to relatively high dietary intakes of vitamin A in the form of retinol. Some studies have suggested, although inconclusively, that high vitamin A levels in the form of retinol may increase the risk of osteoporotic fractures in older women (Conaway et al. 2013, Nordic Nutrition Recommendations 2014).

The present study gives new information on dietary nutrient intakes among heterogeneous older populations. It is clear that older people are a risk group for poor protein intakes, as shown in our study, in which 77% of the entire sample's protein intake was below the RIs. In some vulnerable groups of older people, even intake values below the LI were observed in some micronutrients.

Heterogeneous groups of older people may present with various types of nutritional risks, and in this study even within the groups there were individuals who showed high nutritional risks. Many of the risks contributed to poor cognition, immobility, low MNA scores, and comorbidities, which may have led to poor energy intakes and low nutrient density of the foods consumed. In conclusion, the following points regarding the heterogeneous older population samples' nutrition can be highlighted: as expected, the healthiest and youngest

of the groups (NC) had the best nutrient intakes and diet quality. Older males living alone may have problems in cooking or lack knowledge of nutrition. Older men as spousal CGs may not have the means and knowledge to cook and offer proper meals to their spouses with AD, whereas female CGs may have better knowledge of cooking and housework in general. This was seen in home-dwelling AD females who had LIs of energy and various micronutrients, whereas AD males had better nutrient intakes. Reasonably high percentages of the PSNT participants did not attain the ARs for various micronutrients. On the other hand, they had the highest intakes of PUFAs of all the groups. The ALF residents had the lowest nutrient density, although their energy intakes were relatively high. The ALF residents' poor diet quality was characterized by poor protein, micronutrient, PUFA, and fiber intakes and high processed carbohydrate intakes. These findings may be generalized to older populations, because the study participants represented heterogeneity of the older population varying from healthy older adults to institutionalized older people.

6.2 Sensitivity and specificity of the Mini Nutritional Assessment (II)

Despite the fact that the MNA is a well-validated and widely used instrument, its sensitivity and specificity in identifying those with poor energy and protein intakes in the present study were poor. The MNA may thus not have identified those older people who were at an early stage of developing malnutrition.

The fact that the MNA is very focused on weight loss may have been partly responsible for the findings in the study, since most of the participants in the normal nutritional status group did not have low BMIs, nor were they losing weight. In the screening part of the MNA, three of the six items dealt with recent decreased food intake, weight loss, and BMI (Vellas et al. 1999). The weight criterion (item F) gives maximum points if the BMI is > 23, but does not consider very high BWs (Amella 2008). Some have argued that a high proportion of older people have high BWs, and some re-evaluation should be made of the instrument (Amella 2008). Loss of muscle mass decreases the BEE (Evans 1995). Sarcopenic obesity, in which a considerable part of the lean body mass has been replaced with fat mass, increases with each decade in older people (Benton et al. 2011, Batsis et al. 2013). Older adults with sarcopenic obesity thus have a very low BEE, and at the same time they may be inactive, but not necessarily immobile (item C) (Evans 1995). As a consequence, they may not be losing weight despite poor energy and protein intakes.

In the long version of the MNA, one limitation may be the examiner's lack of familiarity with the requirement of measuring both the midarm and midcalf circumference (Amella 2008). Moreover, demented patients may be unable to answer some of the questions themselves (Sieber 2006). This may be a problem in specific questions (items O and P), in which self-evaluation of the examinee's health in comparison to that of other people of the same age, as well as the subjective opinion of one's nutrition are questioned (Vellas et al. 1999, Guigoz et al. 2006). Moreover, there may be some variation in the responses, depending

on who is interviewed. For example, in a study conducted in an NH environment, considerable differences in the MNA scores were observed when the MNA test results from interviewing the residents were compared with the assessments done by the nursing staff (Kaiser et al. 2009). Furthermore, when a member of a nursing staff fills in the MNA on the behalf of a resident, he/she may not be familiar with the eating habits of an individual (item L), e.g. even though fruits and vegetables may be served daily in some form. Whether the resident actually consumes them may not be as clear.

Despite the low sensitivity and specificity of the MNA in identifying poor energy and protein intakes in this study, the MNA classes were linearly associated with energy, total protein, and nutrient intakes, in which the highest nutrient intakes were in the normal nutritional status group and the lowest in the malnourished group. The instrument recognized more advanced malnutrition risk, but may have failed to identify those with low nutrient intakes at early stages that may lead to malnutrition and poor immunity (Lesourd 2004). It is important to use appropriate dietary assessment tools, such as dietary records, FFQs, IDQs, or other appropriate methods to identify older people with low diet quality and poor protein and micronutrient intakes that may be at risk of malnutrition and frailty at an early stage.

6.3 Nutrition education and cooking classes (III)

In this study, healthy older people who participated in NC classes improved their diet quality as well as vitamin C and fiber intakes. Furthermore, the intervention had a positive impact on the participants' PWB. These findings suggest that NC classes may improve nutrition and PWB of older people.

Preventing the deterioration of nutritional status in older individuals is important. Previous interventions have been targeted at specific groups of older people, including those with AD, their spouses, and cancer survivors (Rivière et al. 2001, Bernstein et al. 2002, Green et al. 2008, Campbell et al. 2009). These interventions have been effective in improving participants' nutrition. Nutritional and lifestyle change studies have also been successful in addressing some of the nutritional issues in healthy older individuals (Bernstein et al. 2002, Clark et al. 2005, Green et al. 2008, Burke et al. 2013). Many of the interventions have been performed by means of minimal intervention, e.g. through phone calls, newsletters, or manuals. However, policy interventions or merely spreading information may only have a weak effect on improving diets (Brambila-Macias et al. 2011). Therefore, a stronger focus on adult learning methods may be necessary for affecting behavioral change (Keller et al. 2004, Capacci et al. 2012). NC classes involving a social aspect with peer support may especially benefit older widowers, male spousal CGs, and other specific groups of older people with limited nutrition knowledge and cooking skills (Keller et al. 2004, 2006, Puranen et al. 2013).

Our findings could be used in planning of tailored intervention for different types of older people's groups. These study results need to be supported in RCTs.

6.4 Nutritional counseling of home-dwelling older people with Alzheimer's disease (IV, V)

In the present study, the home dwelling AD participants in the intervention group increased their protein and calcium intakes as a consequence of tailored nutritional counseling and care, although the primary outcome measure of BW did not change. The participants in the intervention group also improved their HRQoL and experienced fewer falls than those in the control group. This is the first RCT to examine the impact of tailored nutritional counseling and care on the nutrient intake, QoL, and falls of home-dwelling older people with AD.

The nutrient intakes of older AD patients tend to decrease over time as the disease advances (Shatenstein et al. 2007). As a result of the intervention, nutrient intakes increased in the intervention group, but decreased at the same time in the control group. Differences in the intakes of protein and calcium were statistically significant. For this study, a protein intake with a cut-off point of 1.0 g/kg BW was used, which is considered the minimum recommendation for older adults (Bauer et al. 2013). The protein intake at baseline varied widely. Of the participants, 55% had poor (< 1 g/kg BW/d) protein intake. These people would most likely benefit from nutrition intervention.

The HRQoL 15D showed a difference of 0.04 after intervention between the intervention and control groups. In a previous study, an association between the HRQoL and risk of malnutrition was observed (Jiménez-Redondo et al. 2014). A difference of 0.02-0.03 in the 15D score between participant groups is considered clinically significant (Sintonen 2001). The 15D instrument is a generic measure in frequent use among various samples of older adults and shows favorable discriminative and prognostic validity among patients with delirium or dementia (Strandberg et al. 2006). The difference in changes between the intervention and control groups was significant in the total score and in the dimensions of mental functioning, depression, usual activities, and breathing. The ability to cope with usual activities reflecting physical functioning and the maintenance of mental functioning reflecting cognition are significant findings, since few means are still available to support and maintain favorable mental and physical functioning in AD patients. Improvements in breathing and usual activities may indicate improvements in muscle functioning, which may be due to increased protein and micronutrient intake. Depression and mental functioning could also be attributed to improved nutrient intake (Tolmunen et al. 2004, Safouris et al. 2015).

The lower rate of falls in the intervention group may also be explained by improvements in muscle functioning. This may have been due to the higher protein and micronutrient intakes during the intervention. This result was supported by the finding of a study showing

that the physical functioning of older adults may improve with ONSs containing 15 g of protein twice daily, even without physical training (Tieland et al. 2012).

Older people with AD are heterogeneous in their nutrition. Thus, nutritional guidance must be tailored according to their individual needs. In this study, some AD-CG couples with poor diet quality and inadequate nutrient intake needed more intensive guidance and more frequent home visits than those with good nutrition, particularly male CGs, who required more intensive guidance for food-related activities (Puranen et al. 2014). Studies of tailored nutritional guidance in home-dwelling older people are very scarce (Shatenstein et al. 2007, Nykänen et al. 2014). In addition to nutritional advice, the ONSs were used when participants were unable to make necessary changes in their diets. ONSs have positively affected older persons' weight and nutrient intakes decreasing mortality and hospital stays (Milne et al. 2009, Hanson et al. 2011). However, in our study, participants received ONS tailoring only if needed as part of the intervention to complement their daily diet in case they were unable to make the recommended changes in their diet. None of the participants in the intervention group used ONSs during the final assessments. Therefore, the rise in protein intake assessed at 1 year is the result of changes in diet rather than in intake of ONSs. After receiving tailored administration of supplements, the couples became more energetic and interested in making changes to their diets.

This study was the first RCT to investigate the effects of nutritional counseling and care on home-dwelling AD patients and their spousal CGs. The study resulted in increased protein intake, improvement in HRQoL, and decrease in falls in the intervention group. These findings are applicable to home-dwelling AD patients living with their CGs and outline the importance of nutrition in this vulnerable population group. Nutrition should be integrated in the care of this population group.

6.5 Strengths and limitations of the studies presented (I-V)

The strengths of these observational studies included their large sample sizes and diverse older populations resulting from combining of data from various nutritional studies. The studies used similar methods, thus allowing evaluation of energy, macronutrient, micronutrient, and fiber intakes in heterogeneous groups of older people. Combining data gave our study more statistical power, and allowed each MNA group to include a large number of people. Examining the dietary intakes of heterogeneous older populations, different types of groups, and settings of older people were compared in this study, which to my knowledge is the first such study in this respect. Combining data from different studies is also challenging, since not all studies shared the same measurements. Due to the cross-sectional nature of these studies, no causal relationships can be drawn from the results. The number of individuals in groups of older people varied from 54 to 374. Two groups had fewer than 100 participants, and this was also a limitation in comparing heterogeneous older population groups.

The limitation in all of the studies presented here is the fact that assessing food intake is challenging. Food records may be affected by considerable under- or overreporting of the foods consumed, which may cause bias in the studies. However, every effort was made in each of the studies to ensure the correctness of the dietary records. The participants received advice beforehand on how to fill out the food records, and face-to-face interviews or phone calls were made, depending on the study, to confirm the dietary information as accurately as possible. In three of the studies only 1-day food records were utilized (HBS, PSNT, ALF). Trained nurses recorded the dietary intake of the ALF residents and the spousal CGs of the AD patients.

When only the 1-day food consumption was assessed, it may have differed from the person's average food intake over a longer period of time. However, older people often have similar diets, and the food records used were seen as appropriate for recording older people's dietary intakes (Thompson and Byers 1994, Gariballa and Foster 2008). Although the individual food intake may vary on a daily basis, our results are relevant at the group level (Basiotis et al. 1987).

The participants suffering from malnutrition had the lowest protein, micronutrient, PUFA, and fiber intakes and the highest sugar and low-quality carbohydrate intakes, whereas those in the normal nutritional group had the best nutrient intakes and the lowest sugar intake. When the groups of older people were compared, the healthiest and youngest group (NC) had the best nutrient intakes and overall nutrient density, whereas the institutionalized older people presented with the worst nutrient intakes and had the worst overall nutrient density. Some vulnerable groups such as home-dwelling AD women also stood out as having very low energy and nutrient intakes.

These results confirmed the outcomes from previous studies (Gillette-Guyonnet et al. 2000, Sharkey et al. 2002 Guigoz 2006, Shatenstein et al. 2007, Vikstedt et al. 2011). When the people with the lowest reported energy intakes were examined to rule out possible underreporting, the participants who presented with very low energy intakes (> 1.1 x BEE) were mostly ALF residents who were losing weight, had severe malnutrition, and already had extremely low BWs . In the ALF residents or AD females, the subjective underreporting was hardly an issue, since they did not keep the food diaries themselves. Furthermore, to estimate the energy consumption in each group of older people, estimations of energy consumption for TEE were made, using a validated formula by the WHO (1985). All the reported mean energy intakes of the groups in these studies were within the range of the low and high energy consumption calculations (BEE ± 20%), except for the female AD-male CG pair that was discussed earlier. Clearly, these calculations do not rule out possible underreporting of some participants in this study, but rather show that these results are more relevant at the group rather than the individual level (Basiotis et al. 1987). The nutrient data were analyzed with two different programs, but this should not have affected the results, since both of the programs are validated methods for analyzing the nutrient contents of foods consumed.

Nutrition education and cooking classes

The main limitation of the NC classes was the lack of a control group. Furthermore, it was not possible to determine which part of the intervention had positively affected the participants' nutrition, whether it was the increased knowledge of healthy diets, improved cooking skills, or the social effect of the courses. However, the results of the study suggest that the combined effects of the NC classes with social interaction may have positively affected older people's diet quality and nutrient intakes. Due to the lack of resources, the follow-uptime was limited to 4 months, although a longer follow-up would have allowed us to determine whether the improved dietary habits would have been retained. The power of our study was fairly low, and therefore the effect sizes were used with CIs to illustrate the size of the effect of the intervention.

The results of this intervention may have been diluted by the ceiling effect, since the participants were healthy volunteers who were already interested in health and nutritional issues. Even at baseline, they had relatively good diet quality, nutrient intakes, and PWB, but were still able to improve all of the parameters measured. The effect sizes of the change were at best close to medium, which may have been due to the fact that the situation at baseline was already quite favorable. The range of effect size changes was similar to those observed in other intervention studies (Potter et al. 2000, Green et al. 2008).

NuAD study

The strength of the NuAD study was its design. In prior studies of people with AD, nutritional supplements positively affected cognition, BW, and morbidity, but these studies did not assess the nutrient intake of the participants (Keller et al. 2003, Lauque et al. 2004, Manders et al. 2004). The strength of the NuAD study is the fact that people with AD were properly diagnosed, and the questionnaires used were validated. Unlike in previous studies, the present study's design with tailored nutritional guidance allowed the investigators to assess the participants' diets. This type of approach seemed necessary, due to the heterogeneity of the participants' nutrient intakes at baseline (Puranen et al. 2013). Detailed 3-day food diaries of people with AD were collected.

The study had several limitations. Most importantly, the sample size was fairly small, and this type of study with samples of aged home-dwelling AD patients usually has a fairly high number of dropouts (Pitkälä et al. 2013). However, even with this small sample size, improvements in the QoL were shown. To ensure the correctness of the food records, food habits were discussed during the home visits. Weight loss was chosen as the main outcome measure, based on the results of previous studies of persons with AD (Rivière et al. 2001, Lauque et al. 2004, Milne et al. 2009). In contrast to this initial hypothesis, the people participating in this study had reasonably high BMIs; thus weight gain was not encouraged in the AD participants of the intervention group, and, in fact, only 4% of the participants lost BW prior to the study. Furthermore, 67% had a BMI over 24; thus it was clear that BW gain may not have been a relevant aim for this intervention. Only half of the participants were at risk of malnutrition, and none were malnourished. Thus, BW as the main outcome result was the wrong measure. In previous studies in which BW was used

as the outcome measure, the AD participants had more severe dementia and were institutionalized. In Finland, AD patients may be diagnosed earlier, and thus the people in the study may have been in better condition than the older AD participants in previous studies. However, in our sample a large percentage of participants had poor diet quality and low protein and micronutrient intakes.

7. CONCLUSIONS

Of the heterogeneous older populations, 77% had a lower than the RI of protein. Furthermore, a large proportion of both institutionalized and home-dwelling older people had inadequate intakes of various micronutrients. LIs of micronutrients were observed, particularly in vitamins A, D, E, and iron. Even among the healthiest older people, there were a number of individuals at risk of inadequate nutrient intakes. Inadequate nutrient intakes were most frequently observed in the following groups; ALF, AD, PSNT, HBS, and male CGs.

The MNA showed low sensitivity and specificity in identifying older people with low energy and protein intakes. Nutritional status according to the MNA was linearly associated with nutrient intakes, but in each nutritional group, even among those with normal nutritional status according to the MNA, there were individuals with poor energy, protein, and inadequate micronutrient intakes. Thus, the MNA alone may not recognize people at risk of malnutrition at the early stages.

The NC classes improved diet quality, micronutrient intakes, and PWB in home-dwelling older people. The participants were healthy volunteers who already had relatively good diet quality and nutrient intakes, but they were still able to improve their diet with the NC course.

The home-dwelling AD participants increased their protein and calcium intakes as a consequence of tailored nutritional counseling and care in a 1-year RCT. The participants in the intervention group also improved their HRQoL and experienced fewer falls than those in the control group.

As a conclusion, good nutritional status, diet quality, and sufficient protein and micronutrient intakes are essential for the health and well-being of older people. Underlying deficiencies in multiple micronutrients should be identified and treated at the earliest possible time. Nutritional education, tailored nutritional interventions, and high nutritional quality of meals served at SHs and for home-careclients are of the essence in improving the nutrition of older people.

8. IMPLICATIONS FOR THE FUTURE

1. The nutrition of older people is essential for maintaining their health and preventing malnutrition. Most of the heterogeneous older people in our sample received less protein than recommended. Nutritional education of older people should be offered to prevent decline in cognition, development of frailty, and to maintain their health.

2. The MNA is a valid instrument for recognizing malnutrition. However, in our study the instrument had a low capacity for identifying those with low energy and protein intakes who may be at risk of developing malnutrition at an early stage. This fact is crucial to recognize, because it is often the only nutrition-related instrument used in clinical practice.

3. Institutionalized older people are at high risk of malnutrition and should be served high-quality protein- and micronutrient-dense foods. In case of acute stress situations, even greater focus should be on the diet, offering them intensified nutritional care. Our studies suggest that the food served at care facilities for the aged may not be adequately nutritious for this frail older population. This issue should be addressed.

4. The nutrition of older people requires further study, especially in association with protein intakes. Interventions for improving the nutrition of older people should be tailored according to their needs and abilities. Nutrition education, counseling, and combined nutrition and exercise interventions with RCT designs should be planned and executed to determine the most effective and feasible methods for improving diet quality and nutrient intakes and preventing the decline of nutritional status. Studies integrating nutrition and exercise would probably be most beneficial for older people to improve muscle mass, strength, and QoL, as well as to prevent cognitive decline.

5. Community care should integrate nutrition as part of normal care in older individuals. Vulnerable older people should be identified and appropriate care should be applied according to individual motivation and capabilities.

6. NC classes should be offered and organized, especially for older male CGs, widows, and other older people lacking necessary skills. In addition, CGs should be offered support in caring for their dependents and, when necessary, more intense nutritional interventions.

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APPENDICES

BACKGROUND INFORMATION QUESTIONNAIRE FOR THE NUTRITION EDUCATION AND COOKING CLASSES STUDY

Date: ____/____/_____

1. Name: _____
2. Date of birth: _____
3. Weight: _____
4. Height: _____
5. Do you use any nutritional supplements?

    1. Yes
    2. No

If yes, please write down the supplements used:

Nutrition supplement	**Quantity used**	**Since when?**

Do you use any natural products?

1. Yes
2. No

If yes, please specify

_____

Do you have or have you had any of the following diseases?

Diabetes
1. Yes
2. No

Myocardical infarction/heart attack
1. Yes
2. No

Memory disorder (e.g. Alzheimer's disease)
1. Yes
2. No

Stroke
1. Yes
2. No

Transient ischemic attack (TIA)
1. Yes
2. No

Ulcer
1. Yes
2. No

Chronic obstructive pulmonary disease (COPD)
1. Yes
2. No

Pneumonia
1. Yes
2. No

Renal insufficiency
1. Yes
2. No

Cancer
1. Yes
2. No

Chronic venous insufficiency (CVI)
1. Yes
2. No

Liver disease
1. Yes
2. No

Folstein Mini-Mental State Exam

I. **ORIENTATION** (Ask the following questions; correct = ☑)	**Record Each Answer:**	(Maximum Score = 10)
What is today's date?	Date (eg, May 21)	1 ☐
What is today's year?	Year	1 ☐
What is the month?	Month	1 ☐
What day is today?	Day (eg, Monday)	1 ☐
Can you also tell me what season it is?	Season	1 ☐
Can you also tell me the name of this hospital/clinic?	Hospital/Clinic	1 ☐
What floor are we on?	Floor	1 ☐
What city are we in?	City	1 ☐
What county are we in?	County	1 ☐
What state are we in?	State	1 ☐

II. IMMEDIATE RECALL	(correct = ☑)	(Maximum Score = 3)
Ask the subject if you may test his/her memory. Say "ball, "flag," "tree" clearly and slowly, about on second for each. Then ask the subject to repeat them. Check the box at right for each correct response. The first repetition determines the score. If he/she does not repeat all three correctly, keep saying them up to six tries until he/she can repeat them	Ball	1 ☐
	Flag	1 ☐
	Tree	1 ☐
		NUMBER OF TRIALS: _____

III. **ATTENTION AND CALCULATION**		
A. Counting Backwards Test	(Record each response, correct = ☑)	(Maximum Score = 5)
Ask the subject to begin with 100 and count backwards by 7. Record each response. Check one box at right for each correct response. Any response 7 or less than the previous response is a correct response. The score is the number of correct subtractions. For example, 93, 86, 80, 72, 65 is a score of 4; 93, 86, 78 70, 62, is 2; 92, 87, 78, 70, 65 is 0.	93	1 ☐
	86	1 ☐
	79	1 ☐
	72	1 ☐
	65	1 ☐
B. Spelling Backwards Test		
Ask the subject to spell the word "WORLD" backwards. Record each response. Use the instructions to determine which are correct responses, and check one box at right fore each correct response.	D	1 ☐
	L	1 ☐
	R	1 ☐
C. Final Score	O	1 ☐
Compare the scores of the Counting Backwards and Spelling Backwards tests. Write the greater of the two socres in the box labeled FINAL SCORE at right, and use it in deriving the **TOTAL SCORE**.	W	1 ☐
		FINAL SCORE_____ (Max of 5 or Greater of the two Scores)

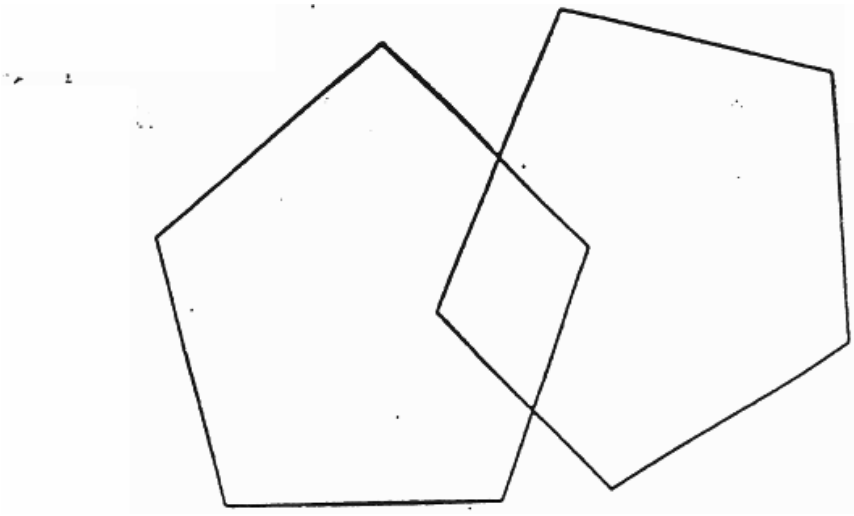
IV. **RECALL**	(correct = ☑)	(Maximum Score = 3)
Ask the subject to recall the three words you previously asked him/her to remember. Check the Box at right for each correct response.	Ball	1 ☐
	Flag	1 ☐
	Tree	1 ☐

V. Language	(correct = ☑)	(Maximum Score = 9)
Naming	Watch	1 ☐
Show the subject a wrist watch and ask him/her what it is. Repeat for a pencil.	Pencil	1 ☐
Repetition		
Ask the subject to repeat "No, ifs, ands, or buts."	Repetition	1 ☐
Three -Stage Command		
Establish the subject's dominant hand. Give the subject a sheet of blank paper and say, "Take the paper in your right/left hand, fold it in half and put it on the floor."	Takes paper in hand	1 ☐
	Folds paper in half	1 ☐
	Puts paper on floor	1 ☐
Reading		
Hold up the card that reads, "Close your eyes." So the subject can see it clearly. Ask him/her to read it and do what it says. Check the box at right only if he/she actually closes his/her eyes.	Closes eyes	1 ☐
Writing		
Give the subject a sheet of blank paper and ask him/her to write a sentence. It is to be written sponataneously. If the sentence contains a subject and a verb, and is sensible, check the box at right. Correct grammar and punctuation are not necessary.	Writes sentence	1 ☐
Copying		
Show the subject the drawing of the intersecting pentagons. Ask him/her to draw the pentagons (about one inch each side) on the paper provided. If ten angles are present and two intersect, check the box at right. Ignore tremor and rotation.	Copies pentagons	1 ☐

DERIVING THE TOTAL SCORE	
Add the number of correct responses. The maximum is 30.	TOTAL SCORE _____
23-30 = Normal / 19-23 = Borderline / <19 = Impaired	Up to Grade 8 Level

Folstein MF, Folstein SE, and McHugh PR, 1975

CLOSE YOUR EYES



Subject Initials _____

CLINICAL DEMENTIA RATING (CDR)

CLINICAL DEMENTIA RATING (CDR):	0	0.5	1	2	3

	Impairment				
	None 0	Questionable 0.5	Mild 1	Moderate 2	Severe 3
Memory	No memory loss or slight inconsistent forgetfulness	Consistent slight forgetfulness; partial recollection of events; "benign" forgetfulness	Moderate memory loss; more marked for recent events; defect interferes with everyday activities	Severe memory loss; only highly learned material retained; new material rapidly lost	Severe memory loss; only fragments remain
Orientation	Fully oriented	Fully oriented except for slight difficulty with time relationships	Moderate difficulty with time relationships; oriented for place at examination; may have geographic disorientation elsewhere	Severe difficulty with time relationships; usually disoriented to time, often to place	Oriented to person only
Judgment & Problem Solving	Solves everyday problems & handles business & financial affairs well; judgment good in relation to past performance	Slight impairment in solving problems, similarities, and differences	Moderate difficulty in handling problems, similarities, and differences; social judgment usually maintained	Severely impaired in handling problems, similarities, and differences; social judgment usually impaired	Unable to make judgments or solve problems
Community Affairs	Independent function at usual level in job, shopping, volunteer and social groups	Slight impairment in these activities	Unable to function independently at these activities although may still be engaged in some; appears normal to casual inspection	No pretense of independent function outside home Appears well enough to be taken to functions outside a family home	Appears too ill to be taken to functions outside a family home
Home and Hobbies	Life at home, hobbies, and intellectual interests well maintained	Life at home, hobbies, and intellectual interests slightly impaired	Mild but definite impairment of function at home; more difficult chores abandoned; more complicated hobbies and interests abandoned	Only simple chores preserved; very restricted interests, poorly maintained	No significant function in home
Personal Care	Fully capable of self-care		Needs prompting	Requires assistance in dressing, hygiene, keeping of personal effects	Requires much help with personal care; frequent incontinence

Score only as decline from previous usual level due to cognitive loss, not impairment due to other factors.

Mini Nutritional Assessment
MNA®

Nestlé Nutrition Institute

Last name: First name:

Sex: Age: Weight, kg: Height, cm: Date:

Complete the screen by filling in the boxes with the appropriate numbers.
Add the numbers for the screen. If score is 11 or less, continue with the assessment to gain a Malnutrition Indicator Score.

Screening

A Has food intake declined over the past 3 months due to loss of appetite, digestive problems, chewing or swallowing difficulties?
0 = severe decrease in food intake
1 = moderate decrease in food intake
2 = no decrease in food intake ☐

B Weight loss during the last 3 months
0 = weight loss greater than 3kg (6.6lbs)
1 = does not know
2 = weight loss between 1 and 3kg (2.2 and 6.6 lbs)
3 = no weight loss ☐

C Mobility
0 = bed or chair bound
1 = able to get out of bed / chair but does not go out
2 = goes out ☐

D Has suffered psychological stress or acute disease in the past 3 months?
0 = yes 2 = no ☐

E Neuropsychological problems
0 = severe dementia or depression
1 = mild dementia
2 = no psychological problems ☐

F Body Mass Index (BMI) = weight in kg / (height in m)^2
0 = BMI less than 19
1 = BMI 19 to less than 21
2 = BMI 21 to less than 23
3 = BMI 23 or greater ☐

Screening score (subtotal max. 14 points) ☐☐
12-14 points: Normal nutritional status
8-11 points: At risk of malnutrition
0-7 points: Malnourished

For a more in-depth assessment, continue with questions G-R

Assessment

G Lives independently (not in nursing home or hospital)
1 = yes 0 = no ☐

H Takes more than 3 prescription drugs per day
0 = yes 1 = no ☐

I Pressure sores or skin ulcers
0 = yes 1 = no ☐

J How many full meals does the patient eat daily?
0 = 1 meal
1 = 2 meals
2 = 3 meals ☐

K Selected consumption markers for protein intake
- At least one serving of dairy products (milk, cheese, yoghurt) per day yes ☐ no ☐
- Two or more servings of legumes or eggs per week yes ☐ no ☐
- Meat, fish or poultry every day yes ☐ no ☐

0.0 = if 0 or 1 yes
0.5 = if 2 yes
1.0 = if 3 yes ☐.☐

L Consumes two or more servings of fruit or vegetables per day?
0 = no 1 = yes ☐

M How much fluid (water, juice, coffee, tea, milk...) is consumed per day?
0.0 = less than 3 cups
0.5 = 3 to 5 cups
1.0 = more than 5 cups ☐.☐

N Mode of feeding
0 = unable to eat without assistance
1 = self-fed with some difficulty
2 = self-fed without any problem ☐

O Self view of nutritional status
0 = views self as being malnourished
1 = is uncertain of nutritional state
2 = views self as having no nutritional problem ☐

P In comparison with other people of the same age, how does the patient consider his / her health status?
0.0 = not as good
0.5 = does not know
1.0 = as good
2.0 = better ☐.☐

Q Mid-arm circumference (MAC) in cm
0.0 = MAC less than 21
0.5 = MAC 21 to 22
1.0 = MAC greater than 22 ☐.☐

R Calf circumference (CC) in cm
0 = CC less than 31
1 = CC 31 or greater ☐

Assessment (max. 16 points) ☐☐.☐
Screening score ☐☐.☐
Total Assessment (max. 30 points) ☐☐.☐

Malnutrition Indicator Score

24 to 30 points	☐	Normal nutritional status
17 to 23.5 points	☐	At risk of malnutrition
Less than 17 points	☐	Malnourished

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For more information: www.mna-elderly.com

INSTRUCTIONS FOR FOOD DIARY

Please write down the beginning and end of each meal, e.g. Breakfast 8:00—8:30. Record all of the foods and drinks consumed and their quantities (e.g. dl, g, slice of bread, 1 apple).

Please record as accurately as possible:

1. The type of spread used on the bread, brand name, and fat%. The quantity and type of bread, e.g. ½ a bun or slice of bread (rye bread, wholegrain, mix-flour bread, white bread, and brand name of the bread). In addition, record the type and quantity of topping on the bread, e.g. 1 slice of cheese 24% fat. The spread can be written down as teaspoons (tsp) or grams (1 tsp = 5 g). Type of milk (fat-free, light, whole milk, and fat %), yogurt (fat%, sugar%, sugar-free, fat-free, light, reduced sugar, etc.).

2. Record juices consumed as accurately as possible; whole juice, juice with added sugar, refreshment drinks, sugar-free drinks, energy drinks. They are best recorded as 1 glass.
3. Coffee, tea, cacao; write down how much sugar/cream and fat%/milk and fat% you add to it.

4. If you add butter, margarine, oil, jam, or marmalade to porridge, please record it as tablespoons (tbs). Please mark down also the type of porridge (rye, wheat, barley, oat, multigrain) and whether it is made with water or milk, and fat% of milk used. The quantity of porridge can best be given as dl.

5. Please record the main meals as accurately as you can. For example, meatballs can be recorded as pieces, sauce as dl, a plate of soup (please record the cooking method as well), salads and cooked or steamed vegetables as dl. Desserts as dl or pieces. Please specify the type of salad dressing (oil, mayonnaise, sour cream, light) and record the quantity as tbs. If you use pure oil as salad dressing, mark for example 1 tbs of olive oil.

6. Fruits can be recorded as natural units, e.g. 1 apple, 1 banana (you can mark down for example big apple or small apple). Berries are best recorded as dl.

1 glass of milk or water is about 1.7 dl, and 1 coffee cup 1.5 dl.

FOOD DIARY NuAD study

Name: _____
Who filled in the diary: _____

Please write down all of the foods and drinks consumed. If there is not enough space, you can continue on the other side of the paper.
Date: _____ Day of the week: _____

1. Breakfast Time: _____
_____
_____
_____
_____

2. Morning snack Time: _____
_____
_____

3. Lunch Time: _____
_____
_____
_____

4. Afternoon snack Time: _____
_____
_____

5. Dinner Time: _____
_____
_____
_____

6. Evening snack Time: _____
_____
_____

7. At night Time: _____
_____
_____

INDEX OF DIET QUALITY

Index of Diet Quality (IDQ)
Instructions: Answer each queston. Choose only one alternative or answer to each question.

1. How many slices of bread do you eat daily?
_____ slices (a whole bun or roll = 2 slices)

2. The bread you mainly consume is
1. rye bread or hard rye bread
2. wholegrain bread
3. white bread
4. I don't eat bread

3. How many times during the week do you eat wholegrain products (e.g. bread, porridge, muesli)?
_____ days (0–7, 0 = less than once a week, 7= every day)

4. What kind of spread do you use on your bread?

1. Nothing
2. Spread with at most 40% fat (e.g. Keiju Keveämpi 30, Keiju Kevyt 40, Flora Kevyt 40, Kevyt Becel 35, Kevyt Levi 40)
3. Spread with 60% fat (e.g. Becel 60, Keiju 60, Kultarypsi 60)
4. Spread with 70–80% fat (e.g. Flora 70, Keiju 70)
5. Spread made of butter-vegetable oil mix (e.g. Oivariini, Enilett)
6. Butter
7. Margarine that contains vegetable stanol or sterols (e.g. Becel pro activ, Benecol)

5. The salad dressing you use is usually

1. vegetable oil-based
2. sour cream-based
3. mayonnaisE- based
4. light dressing
5. I don't use salad dressing

6. How many times a week do you eat fish?
_____ times (0–7, 0 = less than once a week, 7 = every day)

7. The milk or sour milk you consume is usually

1. whole milk
2. light milk or sour milk containing at most 2.5% fat (e.g. ab-sour milk)
3. light milk or sour milk containing 1% fat
4. fat-free milk or sour milk
5. I don't drink milk or sour milk

8. How many times a week do you consume drinkable milk products (e.g. milk, sour milk, jogurts)
_____ times (0–7, 0 = less than once a week, 7 = every day)

9. How many portions of drinkable milk products do you consume daily?
_____ portions (1 portion = 2 dl)

10. How many times a week do you eat vegetables?
_____ times (0–7, 0 = less than once a week, 7 = every day)

11. How many portions of vegetables do you eat a day?
_____ portion (0 = none)
(1 portion = e.g. 1 tomato or approximately 1 dl grated vegetables or 2 carrots)

12. How many days a week do you eat fruits or berries?
_____ days (0–7, 0 = less than once a week, 7 = every day)

13. How many portions of fruits or berries do you eat a day?
_____ portion (0 = none)
(1 portion = e.g. 1 apple or banana or approximately 1 dl of berries)

14. On how many days a week do you drink fruit or berry juices?
_____ days (0–7, 0 = less than once a week, 7 = every day)

15. How many glasses of fruit or berry juice do you drink daily?
_____ glasses (1 class = 2 dl)

16. On how many days a week do you drink sugar-containing refreshment drinks (including energy drinks)?
_____ days (0–7, 0 = less than once a week, 7 = every day)

17. On how many days a week do you eat sweets (including chocolate)?
_____ days (0–7, 0 = less than once a week, 7 = every day)

18. How many times a week do you skip lunch or dinner due to hurry or other reasons?
_____ days (0–7, 0 = less than once a week, 7 = every day)

PSYCHOLOGICAL WELL-BEING QUESTIONNAIRE

1. Are you satisfied with your life?

1. Yes 2. No

2. Do you feel needed?

1. Yes 2. No

3. Do you have plans for the future?

1. Yes 2. No

4. Do you have zest for life?

1. Yes 2. No

5. Are you feeling depressed?

1. Seldom or never
2. Sometimes
3. Often or always

6. Do you suffer from loneliness?

1. Seldom or never
2. Sometimes
3. Often or always

QUALITY OF LIFE QUESTIONNAIRE (15D©)

Please read through all the alternative responses to each question before placing a cross (x) against the alternative that best describes your present health status. Continue through all 15 questions in this manner, giving only one answer to each.

QUESTION 1. MOBILITY

1. ( ) I am able to walk normally (without difficulty) indoors, outdoors, and on stairs.
2. ( ) I am able to walk without difficulty indoors, but outdoors and/or on stairs I have slight difficulties.
3. ( ) I am able to walk without help indoors (with or without an appliance), but outdoors and/or on stairs only with considerable difficulty or with help from others.
4. ( ) I am able to walk indoors only with help from others.
5. ( ) I am completely bedridden and unable to move about.

QUESTION 2. VISION

1. ( ) I see normally, i.e. I can read newspapers and TV text without difficulty (with or without glasses).
2. ( ) I can read papers and/or TV text with slight difficulty (with or without glasses).
3. ( ) I can read papers and/or TV text with considerable difficulty (with or without glasses).
4. ( ) I cannot read papers or TV text either with glasses or without, but I can see enough to walk about without guidance.
5. ( ) I cannot see enough to walk about without a guide, i.e. I am almost or completely blind.

QUESTION 3. HEARING

1. ( ) I can hear normally, i.e. normal speech (with or without a hearing aid).
2. ( ) I hear normal speech with a little difficulty.
3. ( ) I hear normal speech with considerable difficulty; in conversation I need voices to be louder than normal.
4. ( ) I hear even loud voices poorly; I am almost deaf.
5. ( ) I am completely deaf.

QUESTION 4. BREATHING

1. ( ) I am able to breathe normally, i.e. with no shortness of breath or other breathing difficulty.
2. ( ) I have shortness of breath during heavy work or sports, or when walking briskly on flat ground or slightly uphill.
3. ( ) I have shortness of breath when walking on flat ground at the same speed as others my age.
4. ( ) I get short of breath even after light activity, e.g. washing or dressing myself.
5. ( ) I have breathing difficulties almost all the time, even when resting.

QUESTION 5. SLEEPING

1. ( ) I am able to sleep normally, i.e. I have no problems with sleeping.
2. ( ) I have slight problems with sleeping, e.g. difficulty in falling asleep, or sometimes waking at night.
3. ( ) I have moderate problems with sleeping, e.g. disturbed sleep, or feeling I have not slept enough.
4. ( ) I have great problems with sleeping, e.g. having to use sleeping pills often or routinely, or usually waking at night and/or too early in the morning.

5. ( ) I suffer severe sleeplessness, e.g. sleep is almost impossible even with full use of sleeping pills, or staying awake most of the night.

QUESTION 6. EATING
1. ( ) I am able to eat normally, i.e. with no help from others.
2. ( ) I am able to eat by myself with minor difficulty (e.g. slowly, clumsily, shakily, or with special appliances).
3. ( ) I need some help from another person in eating.
4. ( ) I am unable to eat by myself at all, so I must be fed by another person.
5. ( ) I am unable to eat at all, so I am fed either by tube or intravenously.

QUESTION 7. SPEECH
1. ( ) I am able to speak normally, i.e. clearly, audibly and fluently.
2. ( ) I have slight speech difficulties, e.g. occasional fumbling for words, mumbling, or changes of pitch.
3. ( ) I can make myself understood, but my speech is e.g. disjointed, faltering, stuttering or stammering.
4. ( ) Most people have great difficulty understanding my speech.
5. ( ) I can only make myself understood by gestures.

QUESTION 8. EXCRETION
1. ( ) My bladder and bowel work normally and without problems.
2. ( ) I have slight problems with my bladder and/or bowel function, e.g. difficulties with urination, or loose or hard bowels.
3. ( ) I have marked problems with my bladder and/or bowel function, e.g. occasional 'accidents', or severe constipation or diarrhea.
4. ( ) I have serious problems with my bladder and/or bowel function, e.g. routine ‘accidents', or need of catheterization or enemas.
5. ( ) I have no control over my bladder and/or bowel function.

QUESTION 9. USUAL ACTIVITIES
1. ( ) I am able to perform my usual activities (e.g. employment, studying, housework, freE-time activities) without difficulty.
2. ( ) I am able to perform my usual activities slightly less effectively or with minor difficulty.
3. ( ) I am able to perform my usual activities much less effectively, with considerable difficulty, or not completely.
4. ( ) I can only manage a small proportion of my previously usual activities.
5. ( ) I am unable to manage any of my previously usual activities.

QUESTION 10. MENTAL FUNCTION
1. ( ) I am able to think clearly and logically, and my memory functions well
2. ( ) I have slight difficulties in thinking clearly and logically, or my memory sometimes fails me.
3. ( ) I have marked difficulties in thinking clearly and logically, or my memory is somewhat impaired.
4. ( ) I have great difficulties in thinking clearly and logically, or my memory is seriously impaired.
5. ( ) I am permanently confused and disoriented in place and time.

QUESTION 11. DISCOMFORT AND SYMPTOMS
1. ( ) I have no physical discomfort or symptoms, e.g. pain, ache, nausea, itching, etc.

2. ( ) I have mild physical discomfort or symptoms, e.g. pain, ache, nausea, itching, etc.
3. ( ) I have marked physical discomfort or symptoms, e.g. pain, ache, nausea, itching, etc.
4. ( ) I have severe physical discomfort or symptoms, e.g. pain, ache, nausea, itching, etc.
5. ( ) I have unbearable physical discomfort or symptoms, e.g. pain, ache, nausea, itching, etc.

QUESTION 12. DEPRESSION
1. ( ) I do not feel at all sad, melancholic, or depressed.
2. ( ) I feel slightly sad, melancholic, or depressed.
3. ( ) I feel moderately sad, melancholic, or depressed.
4. ( ) I feel very sad, melancholic, or depressed.
5. ( ) I feel extremely sad, melancholic, or depressed.

QUESTION 13. DISTRESS
1. ( ) I do not feel at all anxious, stressed, or nervous.
2. ( ) I feel slightly anxious, stressed, or nervous.
3. ( ) I feel moderately anxious, stressed, or nervous.
4. ( ) I feel very anxious, stressed, or nervous.
5. ( ) I feel extremely anxious, stressed, or nervous.

QUESTION 14. VITALITY
1. ( ) I feel healthy and energetic.
2. ( ) I feel slightly weary, tired, or feeble.
3. ( ) I feel moderately weary, tired, or feeble.
4. ( ) I feel very weary, tired, or feeble, almost exhausted.
5. ( ) I feel extremely weary, tired, or feeble, totally exhausted.

QUESTION 15. SEXUAL ACTIVITY
1. ( ) My state of health has no adverse effect on my sexual activity.
2. ( ) My state of health has a slight effect on my sexual activity.
3. ( ) My state of health has a considerable effect on my sexual activity.
4. ( ) My state of health makes sexual activity almost impossible.
5. ( ) My state of health makes sexual activity impossible.

USE OF HEALTH SERVICES

Please indicate in the table the health services you have used during the last 6 months.

Name of the respondents:

How many times have you had one of the following listed in the table during the last 6 months?

	AD participant /times	Spousal caregiver /times
1. Cold		
2. Fall		
3. Hospital visit		
4. Polyclinic visit		
5. Urinary infection		
6. Other illnesses that required antibiotic medication		

More information:

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