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Aspects of Nutrition in Geriatric Patients

Especially Dietary Assessment, Intake and Requirements

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LUND UNIVERSITY
Malmö 2002

Printed in Sweden
Bloms i Lund Tryckeri AB, Lund 2002
ISBN 91-628-5350-3

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Abstract

The aim of this thesis was to develop and test the feasibility of a dietary record routine, where nursing staff assess the patient's food and fluid intake based on standardised portion sizes and household measurements.

The energy intake (EI) was studied with a dietary record in 61 geriatric patients. During the 6-month follow-up 11 patients died and an EI below median (1378 kcal) was associated with an age adjusted increased 6-month mortality risk, odds ratio 12.5. In the reproducibility study the dietary intake of 81 geriatric patients was recorded for two periods of 7 consecutive days. The mean difference in EI between the two periods was 4%. In the validity study total energy expenditure (TEE) was measured with the doubly labelled water (DLW) method concurrently using the dietary record routine in a 7-day recording in 31 body weight stable geriatric patients. The dietary record routine overestimated EI by 8% compared to DLW-measured TEE. In order to explore the accuracy of different equations to predict the TEE, 13 equations developed for the elderly were tested against DLW-measured TEE in 31 geriatric patients. The mean estimated physical activity level was 1.2. Three out of 13 equations could best predict TEE. Out of 81 patients 28% were classified as having a protein-energy malnutrition. Out of 220 patients 62% had an EI below the calculated energy requirements. Almost the entire EI took place within 9 hours during daytime.

Conclusions: The 7-day dietary record routine seems to have a good reproducibility and validity in assessing the intake of energy and fluids in geriatric patients. However, the nursing staff seemed unable to ensure that the patients' individual dietary needs were met. The low dietary intake indicates a need for general daily dietary supplementation to all geriatric patients.

List of publications

This thesis is based on the following papers which are referred to by their roman numerals:

I Elmståhl S, Persson M, Andren M, Blabolil V.
Malnutrition in geriatric patients: a neglected problem?
Journal of Advanced Nursing 1997;26:851-5.

II Persson M, Elmståhl S, Blabolil V.
The reproducibility of a new dietary record routine in geriatric patients.
Clinical Nutrition 2002;21:15-25.

III Persson M, Elmståhl S, Westerterp KR.
Validation of a dietary record routine in geriatric patients using doubly labelled water.
European Journal of Clinical Nutrition 2000;54:789-96.

IV Persson M, Elmståhl S, Ulander K.
Predicting energy needs in geriatric patients.
Submitted for publication 2002.

V Persson M, Elmståhl S, Ulander K.
Dietary intake and mealtime habits in geriatric patients.
Submitted for publication 2002.

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Content

Abbreviations

ADL	Activities in daily life
BIA	Bioelectric impedance analysis
BMI	Body mass index
BMR	Basal metabolic rate
BW	Body weight
CI	Confidence interval
DLW	Doubly labelled water
EE	Energy expenditure
EI	Energy intake
FBCE	Food-based classification of eating episodes
FI	Fluid intake
FM	Fat mass
FFM	Fat free mass
NNR	Nordic nutrition recommendations
OR	Odds ratio
PAL	Physical activity level
PAR	Physical activity ratio
PEM	Protein-energy malnutrition
RDI	Recommended daily intake
RMR	Resting metabolic rate
RMSE	Root mean square error
RN	Registered Nurse
SD	Standard deviations
SNR	Swedish nutritional recommendations
TBW	Total body water
TEE	Total energy expenditure
TWI	Total water intake
WI	Water intake

Introduction

Food and nutrition are fundamental and central areas in life. Without food and nourishment, there is no life. Hunger is a biological drive, but in humans, food and eating are also a great part of social life and a way to satisfy different kinds of psychological needs [1]. An adequate food intake and an adequate nutritional status are basic requirements of good health.

Providing patients with a dietary intake that meets individual needs is an essential task for all health care professionals in nutritional care. It is especially important in the care of hospital patients and the institutionalised frail elderly living in sheltered housing such as nursing homes and community resident homes. An adequate nutritional status is also the key point to successful rehabilitation of patients. Helping patients to eat and drink adequately is one of the fundamental basic principles of nursing care [2].

The honourable Florence Nightingale observed over 140 years ago that many of the patients did not have a sufficient dietary intake as she wrote that: ***"Every careful observer of the sick will agree in this that thousands of patients are annually starved in the midst of plenty…"*** [3]*(page63)*. Presently 140 years later, it is still common to encounter patients admitted to hospital with unnoticed signs and symptoms of malnutrition. As this information has been available for so long, we should ask why malnutrition still remains as a problem? Part of the answer may depend one the difficulties involved in identifying patients who are malnourished or at risk of developing malnutrition.

The theoretical inspiration to this thesis has come from Virginia Henderson's work of "Basic Principles of Nursing Care" [2] and the so-called "*Värnhemsteorin* (the Värnhem theory)" [4]. In "Basic Principles of Nursing Care" Virgina Henderson wrote: ***"There is no more important element in the preparation for nursing than the study of nutrition."*** [2]*(page 21)*.

Malnutrition

The term malnutrition refers to an imbalance between dietary needs and dietary intake, where insufficient intake of macronutrients results in a loss of weight, whereas an excess of dietary intake leads to overweight. However, the term malnutrition has come to describe a condition of undernourishment regardless of the cause [5] and this is how the term is used in this thesis. An insufficient dietary intake can lead to malnutrition. In malnutrition there is an imbalance between energy and nutrient intake on one hand and energy and nutrient needs on the other. The most common type of malnutrition in patients and in care of the elderly in Sweden, is a combination of insufficient intake of protein and energy compared to the individual needs over a period of time, leading to a protein-energy malnutrition (PEM) [5].

"Primary malnutrition" is mostly seen in persons who are dependent on others for nourishment and especially vulnerable are infants, children, prisoners, disabled, mentally ill and elderly [6]. "Secondary malnutrition" is often related to different diseases, disturbing appetite, digestion, absorption or utilisation of nutrients [6]. The aetiology of malnutrition in the elderly is multifactorial, and a number of causes of PEM have been identified, including medical, social and environmental causes [7, 8]. Different medical conditions can change metabolism or absorption or cause excessive losses, and dietary intake can be impaired by e.g. psychiatric disorders and functional incapability due to movement disorders or swallowing problems [7, 9]. The hospital conditions can also be important for adequate dietary intake. Appropriate meals at hospitals include an organisation of the mealtimes during the day, prepared dishes adjusted for patients with denture or swallowing problems, serving aides for disabled, sufficient time for the nursing staff to help dependent patients and an attractive milieu at mealtime. These are all factors that have been shown to substantially influence dietary intake [7, 10-12].

Malnutrition in geriatric patients is an important clinical and public health problem. One important factor contributing to its prevalence appears to be the failure of health care professionals to recognise its signs and identify patients with malnutrition or at risk of becoming malnourished [13-15]. Several studies have shown that patients with malnutrition are not diagnosed correctly [13-15] and that documentation in medical and nursing records is insufficient [14, 16-18]. A high rate of malnutrition in elderly patients have been noted in various clinical settings by many investigators over the last few decades [5, 9, 15, 19-27]. A summary done by the Swedish National Board of Health and Welfare of 25 published Swedish studies during the last 20 years, comprising a total of 5120 patients in different type of wards, showed a mean PEM prevalence of 28% [5]. No major improvements were noted in the prevalence of PEM during the past decades, but different methods were used to assess PEM [5].

Malnutrition is associated with complications such as reduced body weight, loss of appetite, decreased physical ability [28, 29], increased incidence of decubitus [30-32], deterioration of immune function [33], increased risk of infections [34-36], prolonged hospitalisation [37-40], and a high mortality rate [21, 40]. Malnutrition in patients not only cost the health care system a lot of money [5, 39, 41-45], but above all it causes a great deal of suffering for the individual and as a final and ultimate outcome, it is highly correlated with a premature death [21, 40].

Classification of malnutrition

There is no single "golden standard" to classify/diagnose malnutrition, although a number of indicators exist. No single measurement can give a complete answer to the question of a patient's nutritional status. The choice of variables used to classify malnutrition can have a direct effect on the proportions of subjects classified with malnutrition. In a study by Joosten et al [46] the proportions of geriatric patients

classified with malnutrition varied between 6-85% depending on the variables, the combination of variables and cut-off limits used. So even if a high sensitivity (i.e. the proportions of patients with the "disease" who have a positive test) is desirable in determing malnutrition and nutritional status [5], the side effect is often a fall in specificity (i.e. the proportions of patients without the "disease" who have a negative test) [47]. A moderate undernutrition may not be easily detected either because of a lack of obvious signs and symptoms, or a mixture of different signs and symptoms, as a result of deficiencies in several nutrients [48]. This may have an impact on the assessment of patients nutritional status.

Both anthropometric and biochemical parameters have been used in studies to assess nutritional status. Usually a combination of anthropometric and biochemical parameters and sometimes also the dietary intake, are used to classify PEM .

Anthropometric assessment

Body weight (BW) is one of the most important measurements in assessing nutritional status. Body weight is often used as an indicator of nutritional status. Cut-off levels are for instance a weight loss of 10% or more during the last six months [49]. However, even if unintentional weight loss of 10% or more can be a good prognosticator of clinical outcome, sometimes it can be difficult to determine the true weight loss [50]. A cut-off level of 10% might be too high in the elderly and it has been suggested that all unintentional weight loss in the elderly should be consider a risk factor [51].

Body weight is also used as a part of Body Mass Index (BMI) [52, 53], weight index [54] and "ideal body weight" [52, 55]. "Ideal body weight", weight index and BMI also requires a measurement of stature. In geriatric patients measurement of stature can be problematic since not all patients can stand in upright and correct position [52, 56]. Furthermore there is a general decline in the stature in the elderly due to vertebral compression, loss of muscle tone and postural slump [56]. Results of a longitudinal population study in Göteborg, Sweden, have shown a mean body height decrease of 4.9 cm in women and 4.0 cm in men, and a mean BW decrease of 5.1 kg in women and 3.2 kg in men, between 70 and 95 years of age [57]. The cut-off values used for BMI (19/20-24/25) are aimed at adults while the cut-off values in the elderly (>70 years of age) are uncertain [53]. Research indicate that cut-off values for the elderly should be different from those now used for adults [56, 58]. In the elderly BMI 24-29 has been suggested as appropriate [51], but this has been proven yet. An alternative to BMI in the elderly is weight index based on normal values of BW for gender, age and height [54], and often a value 20% below normal (mean) value are being used as a cut-off value for underweight.

Other anthropometric measurements used are skinfold measurements, such as triceps skinfold and subscapular skinfold, to estimate the size of subcutaneous fat depots in the body, which in turn provides an estimate of the total body fat [52].

Different circumference measurements such as calf and mid-upper-arm circumference provides an estimate of both subcutaneous fat and muscle mass [52, 56]. To estimate the total body muscle mass in the body, an estimate of the mid-upper arm muscle area is often used. The mid-upper arm muscle can be calculated using the values from triceps skinfold and mid-upper-arm circumference [52, 59].

Biochemical assessment

Several biochemical tests are used in assessing nutritional status [60]. Traditionally Serum/Plasma Albumin has been used in assessing PEM, where low values (<36 g/L) are used as an indicator of ongoing catabolism [61]. However, even if there is an association between low Serum/Plasma Albumin levels and an increased morbidity and mortality, there are many conditions which have an effect on the Serum/Plasma Albumin level, making the interpretation indistinct [61] and therefor the use of Serum/Plasma Albumin as a nutritional indicator has been criticised [62]. Low Serum/Plasma Albumin values may also be an indicator of on-going inflammation. Serum/Plasma Orosmucoid or C-reactive protein is therefore often analysed simultaneously to rule out an infection [63]. Serum/Plasma Albumin levels do not reflect immediate changes, as it has an 18 days turnover time [60]. A quicker response is Serum/Plasma Prealbumin (Transthyretin) with two days turnover time [60]. Other commonly used biochemical tests are for example Serum/Plasma Transferrin and Insulin-Like Growth Factor I [60].

Screening tools

During the last decades several screening tools, aiming for clinical use in detection of patients at risk of malnourishment/malnutrition, have been published. Such screening instruments/tools are for example: Subjective Global Assessment (SGA) [64, 65]; Patient-Generated Subjective Global Assessment (PG-SGA) [66]; Mini Nutritional Assessment (MNA) [67, 68]; Nutrition Screening Initiative (NSI) including Determine Your Nutritional Health [69, 70]; Nutrition Risk Classification [71]; Nutrition Assessment Tool (NAT) [72]; Derby Nutrition Score (DNS) [73]; Nutrition Risk Assessment Tool for patients in the community [74]; Screening for malnutrition [75] and Modified Nutrition Questionnaire for Elderly (MNQE) [76]. These screening tools often use a combination of items such as anthropometric measurements, dietary intake, the patients function and general health. Some of the screening tools have been tested in validation studies.

Although the underlying cause of PEM can not always be treated, the effect and symptoms of malnutrition can to some degree be prevented or reduced if subjects with poor nutritional status are identified [77]. This can be achieved by monitoring BW changes, food intake or anthropometric and biochemical data, depending on the medical condition. Enteral treatment and support with dietary supplements have been shown to reduce morbidity, mortality and length of hospital stay in elderly patients [78, 79].

Dietary and energy requirements

Knowledge of the nutritional needs in the elderly is in an early phase since most of the research has been done in children and younger adults. For many years it was believed that the requirements for the elderly ought to be the same as for middle-aged people. It is not until lately that recommended dietary intake (RDI) have been specified for the elderly [80], and there is an awakening interest and growing knowledge about dietary needs of the elderly [81-83]. In general terms, the nutritional needs, according to present knowledge, is the same as in middle-aged adults with some exceptions. The energy needs decreases, mostly due to a changed body composition with smaller amounts of muscle tissue and a lower physical activity. However, the technique with doubly labelled water (DLW) has shown that the total energy expenditure (TEE) is high in healthy free-living elderly [84-86]. There does not seem to be any consensus about the protein requirements in the elderly and it has been suggested that there is an increased need compared with middle-aged people. However, the protein requirements of frail elderly is still uncertain [87, 88]. There is need for an increased intake of vitamin D, especially in the elderly who not are exposed to much sunlight. Furthermore, there seem to be a deteriorating capability in the skin and body of the elderly to produce vitamin D [89], making daily outside visits in the sunlight [90] and a higher vitamin D intake even more essential in the elderly. Vitamin D also has a part in prevention of osteoporosis, making an increased intake particularly important in elderly women. There is also need of an increased intake of calcium, especially in women, as a part of prevention of osteoporosis [91]. In the chronically ill and frail elderly, there is no definite dietary recommendations. Both the Nordic Nutrition Recommendation (NNR) [92] and the Swedish Nutrition Recommendations (SNR) [93] are aimed at healthy people.

The FAO/WHO/UNU Expert Consultation has defined energy requirement as: ***"The energy requirement of an individual is the level of energy intake from food that will balance energy expenditure when the individual has a body size and composition, and level of physical activity consistent with long-term good health; and that will allow for the maintenance of economically necessary and social desirable physical activity."*** [94] *(page 12)*

The basal metabolic rate (BMR) of an individual can be defined as the minimal rate of energy expenditure compatible with life [95]. Basal metabolic rate can be measured under standardized conditions or be calculated with a reasonable accuracy using different equations [96]. Since BMR constitutes about 60-80% of a person's total energy expenditure (TEE), it forms the basis for assessment of energy requirements in adults [95, 96].

The daily energy requirements can be defined as an individual's energy needs to support optimal physical functions. To correctly estimate patients' energy requirements is essential in providing an optimal nutritional care. An insufficient energy supply, as a result of incorrect recommendations for the elderly, can have considerable negative influence on a patient's health conditions.

Methods to assess dietary intake

Various methods of assessing dietary intake can be used to identify patients at risk of becoming malnourished [52, 97]. Retrospective methods include dietary history, food frequency questionnaires and 24-hour recalls, whereas prospective methods include the use of dietary records and duplicate meals. Assessment of the dietary intake of hospitalised patients can either be self-administered by the patients [98] or observed by the staff [99]. Sometimes the observation method is not designed to cover a complete 24 hours time period, but only to assess the intake at major meals [100]. The method of choice for the collection of food consumption data and for monitoring nutritional status in geriatric patients is the staff-administered dietary record [97], since the findings are not influenced by various kinds of illness and levels of cognitive impairment that are common in this population. Owing to intra- and interpersonal variations, food and fluid intake must be recorded for several days before the patients' intakes can be classified [97, 101, 102]. It has previously been suggested that a 7-day period is sufficient to gain enough information about the food intake to be able to rank and categorise 80% of individuals correctly, according to the distribution of energy-producing nutrients (fats, carbohydrates, and protein) in the diets, and overcome intra- and interpersonal variations in the distribution [102, 103].

Dietary recording can be used as a screening tool to detect patients at risk of malnourishment. However, dietary record could be time consuming for the nursing staff, especially if several patients are assessed in parallel. Therefore, there is a need to develop a dietary record routine with standardised portion sizes, and a guide with the most common food items, to simplify the registration and to improve precision. Self-administered estimated dietary intake records have been used in large studies in the community [103-105] and even in studies of the elderly [106]. Simple staff-administrated records to estimate patients food intake have come in use during the last decade in the Swedish health system [107, 108], but the accuracy of these records have not before been evaluated.

Fluid intake

The recommended daily fluid intake in elderly people are 30 mL/kg BW [109]. However, it is not clear whether this amount refers to fluid intake (FI) or to water intake (WI), calculated from both food and fluid intake. Methods of identifying fluid imbalance in hospitalised geriatric patients are also lacking. This population is at risk for dehydration, since the elderly have a diminished sensation of thirst and are less able to regulate their fluid balance [110, 111]. If left untreated, dehydration can result in death in many cases [112, 113]. Dehydration is poorly defined and its clinical signs can be vague, especially in the elderly [114, 115]. Water balance studies, particularly those that focus on water intake in weight-stable geriatric patients, may provide information which can help to better identify dehydration in this susceptible population and diminish associated mortality rates. Previous published studies have focused mainly on nutrient intake and not on FI.

Mealtime habits

Dietary intake is usually described as a mean daily intake of macronutrients (fats, carbohydrates and proteins) and micronutrients (vitamins and minerals) [116], while the mealtime habits not usually are reported. Little has yet been published about eating periodicity in geriatric patients, that is, the frequency of eating events, or eating episodes, of various food compositions, the diurnal variations of eating events (meals and snacks) across the 24-hour day, the role of eating events as major contributors of energy and nutrients, and/or the relationship between timing or frequency of eating and nutritional status [117]. The Food-based Classification of Eating Episodes (FBCE) is a tool developed to categorise eating events and can be used to objectively classify the diurnal variations of eating [117].

Reproducibility of dietary records

The reproducibility of assessing the dietary intake is the ability of an instrument to produce the same results on two or more different occasions under the same conditions, assuming that nothing has changed between the occasions [97]. An evaluation of test-retest reliability or reproducibility can be seen as a way to describe the stability of the method [118]. Numerous studies have used dietary records as the reference method in validating 24-hour recalls, diet history and food frequency charts on both a nutrient level and a food item level [97, 119, 120]. Most studies on the reproducibility of food records have been using weight records in younger free-living subjects. Only a few studies have been published on the reproducibility of estimated dietary records [121-123]. No previously published reproducibility study of an estimated dietary record assessing both energy and fluid intake in geriatric patients where the staff has done the recording, has been found.

Little attention has been paid to the reproducibility of dietary methods of assessing fluid intake. However, this is an important area since the elderly have a diminished sensation of thirst and are less able to regulate their fluid balance [110, 111]. No previously published studies on the reproducibility of water and fluid intake in geriatric patients has been found.

Validity of dietary records

Validity can be seen as the degree which an instrument measures what it is supposed to measure [118]. According to Buzzard [124] there are three major aspects of assessing the validity of dietary records: how accurate the individuals dietary intake is recorded, and how well the food composition database and the coding reflect the overall composition of the actual foods eaten, and how well the selected days of recording represents the usual individual intake.

The DLW method can be used to assess TEE and is thereby an independent method to assess the validity of dietary records in assessing EI [125, 126]. However, no study

has been previously performed on elderly hospitalised patients using a 7-day dietary record routine and DLW concurrently. It is important to validate estimated EI in this group of patients, if the comparison of EI with recommended dietary amounts for hospitalised elderly should be meaningful.

Total energy expenditure

Different techniques are available to estimate TEE in humans such as measurement of oxygen consumption, minute-by-minute heart rate monitoring, motion sensor techniques such as using the accelerometer, and the DLW method [127].

The DLW method is an isotope-based technique to measure TEE. The technique builds on the knowledge on how the stable isotopes deuterium (2^{H}) and oxygen 18 (18^{O}) distributes in and excrete from the body. The technique was developed in the 1950s and in the late 1970s the DLW method was used in small animals, and in 1980s in humans [125, 126]. The "golden standard" today for estimating TEE in a real-life situation in humans is the DLW method [128]. One of the advantages of DLW is that the estimate of TEE can be done in a person's normal life situation, in contrast to calorimetry, with which you are limited to laboratory settings [127]. Disadvantage is the technically difficult sample analysis, and it takes several weeks from the start until the analyses are finished, making the method unfit for clinical use. The error of the analytical precision of the DLW method has been reported to be in the range of ±3-6% [125, 129-131]. During the last 20 years the DLW method have been used in many studies on human TEE. However, not many studies have thus far assessed TEE using the DLW method in frail elderly and geriatric patients.

Body weight is closely associated with BMR and many studies have indicated that fat-free mass (FFM) has a high correlation with TEE [132, 133], at least in healthy and active, free-living younger adults [134, 135]. Fat-free mass can be defined as body mass minus body fat and is similar to, but not identical with, lean body mass [136, 137]. The effect of the FFM on BMR is mainly contributed by the metabolically active organs and muscles [94], with the brain, liver, kidneys and heart accounting for about 60% of the BMR in humans [138]. However, TEE can also be affected by physical activity [139, 140] and gender [141-143]. Ageing is associated with a decrease in BMR that has been attributed to an age-related decline in FFM and an increase in body fat [144, 145]. Some studies suggest that differences in FFM between younger and older people do not fully explain the differences in BMR, and suggest that ageing is associated with an alternation in tissue energy metabolism [146], however this has not yet been proven [147]. In the elderly, not only FFM, but also fat mass (FM), fat distribution, total body water (TBW), and aerobic capacity seem to have an influence on the BMR and the decline in BMR with age [143, 148-151].

Body composition in humans changes throughout life [53]. Predictions of BMR and TEE can be influenced by body composition changes if these variables are included

in the BMR equations. Results of a longitudinal population study in Göteborg, Sweden, has shown changes in body composition with a decrease in BW, stature, and TBW from the age of 70 [136, 152, 153]. Furthermore, the study showed a mean body height decrease of 4.9 cm in women

In the report of a joint FAO/WHO/UNU Expert Consultation [94], the principle of relying on estimates of energy expenditure was adopted, rather than calculating EI from dietary surveys, for estimating energy requirements of adults. It was suggested that energy requirements could be expressed as multiples of the BMR. In the FAO/WHO/UNU's method of estimating energy requirements, an assessment of the physical activity level (PAL) is also necessary. The PAL has been defined as TEE divided by BMR [154]. The energy cost, that is, the physical activity ration (PAR), of single activities such as sleeping, sitting and walking, could be added to a total sum for a 24-hour period, and then divided by 24 to obtain an average PAL for the whole period [94]. The FAO/WHO/UNU concept implies that the energy requirement can be estimated by multiplying the BMR with an appropriate activity factor.

Many equations have been published for predicting and calculating human energy requirements, especially in hospitalised patients [155], although not all of them can be applied to geriatric patients. The equations often use different variables in the estimation, such as anthropometric measurements, BW, stature, age, and gender. More than ten different equations adopted for the elderly have been published. No previous study has been found which compare the accuracy of all these different equations in geriatric patients using one and the same reference method.

Ageing

Swedish people are getting older and live longer. In the past 30 years the average life expectancy at birth has increased with almost 6 years in women as well in men. The average life expectancy in the year 1970 was 76 years at birth and 16 years at the age of 65 in women, the corresponding figures in men was 72 years and 14 years, respectively. In the year 2000 the average life expectancy had increased to 82 years at birth and 20 years at the age of 65 in women, the corresponding figures in men was 77 years and 17 years, respectively. In the year 2001 the population in Sweden was 8.9 million and of whom 17.2% (1.5 million) was 65 years of age and older. In 1970 corresponding figure was 13.8% and the predicted value in 2030 is 23.3%. [156]

Even if the elderly in general live longer, stay healthier longer and can manage on their own more than before [157], the care dependency of the elderly and the nursing workload in sheltered housing has increased over the past 10 years [158-160]. Of all people in Sweden aged 65 years and older, 8% (128 600) lived permanently in sheltered housing in October 2001, of whom 78% (92 800) were of age 80 years and older [161]. Of the elderly in sheltered housing almost 22% are totally dependent during mealtime and 57% needed support in some way during mealtimes [162].

The elderly use a great deal of the hospital-resources. About 55% of the total number of in-hospital days in Sweden were in 1999 used by people 65 years of age and older [163]. Even if people 85 years of age and older are only 2.3% of the population in Sweden [156], they use about 12% of the total numbers of days in-hospital stays [163].

Most of the geriatric patients have chronic diseases and multiple diagnosis. The number of mean diagnosis in a large Dutch population study were 2.6 in females age 60-79 and 3.6 in the age-group 80+ years, corresponding values in males were 2.4 and 3.2, respectively [164]. The use of drugs are high in the elderly, also indicating the high morbidity in the elderly. In a study of 681 elderly in Sweden, 81 years of age and older, the mean number of drugs used were 4.6 [165]. A longitudinal study in the elderly shows that the number of drugs used increases with age [166]. The illness can cause malnutrition in the elderly, and the symptoms of the diseases can mask and hide early symptoms of malnutrition irrespectively of the cause, making it even more difficult to diagnose the malnutrition. Some drugs can cause weight loss in the elderly, while others can decrease the appetite or cause malabsorption [7].

Even if food and EI decreases with age in the elderly, mainly due to a decreased physical activity and body composition changes, malnutrition in the elderly should not be misinterpreted as part of normal ageing.

During the past years the public debate in Sweden conserning malnutrition and care of the elderly living in sheltered housing has been intense, fuelled by several reports, among them a report by the Swedish National Board of Health and Welfare [5]. However, to date it has not been investigated whether this debate has had a direct influence on the nutritional care of the elderly, or if it has led to an increased dietary intake in geriatric patients.

Aims

General aim

To develop and test the feasibility of a dietary record routine, which assesses geriatric patients' food and fluid intake, based on standardised portion sizes and household measurements, in a clinical setting.

Specific aims

- To investigate the occurrence of low dietary intake, dietary habits, and any association with mortality at a 6-months follow-up, using a dietary record routine as a screening instrument. (I)

- To describe the prevalence of protein-energy malnutrition among geriatric patients in nursing homes. (II)

- To test the reproducibility of a 7-day estimated dietary record routine with standardised portion sizes and household measuring in a clinical setting. (II)

- To validate a 7-day estimated dietary record routine with standardised portion sizes and household measuring in a clinical setting with the doubly labelled water method as reference method. (III)

- To explore total energy expenditure levels and physical activity levels in geriatric patients. (IV)

- To explore the accuracy of different equations for calculation of basal metabolic rate to predict total energy expenditure, combined with estimated physical activity level, using doubly labelled water as a reference method, in geriatric patients. (IV)

- To describe dietary intake and mealtime habits in relation to dietary requirements and to explore differences in dietary intake, in geriatric patients, over a four year period. (V)

- To describe the prevalence of geriatric patients at risk of developing malnutrition. (V)

Methods and population

Population (paper I-V)

The study population was recruited from ten sheltered houses, seven nursing homes and three community resident homes, in a Swedish municipality during 1995, 1996 and 1998-1999 (see Figure 1 for details). Different wards and patients were observed each year.

Inclusion criteria

In paper I, II and V the inclusion criteria were patients in nursing/community resident homes with the ability to orally ingest food and fluids.

In paper III and IV the inclusion criteria were patients in nursing/community resident homes, with an ability to orally ingest food and fluids, and a stable BW, defined as a maximum change of ±4% during the past 4 months or ±2% during the past 2 months.

Exclusion criteria

In paper I, II and V the exclusion criteria were patients with parenteral or enteral nutrition, acute illness, or terminal conditions, i.e. where death was expected within a few weeks.

In paper III and IV the exclusion criteria were patients with parenteral or enteral nutrition, acute illness, inflammatory conditions, anaemia, hypo- or hyperthyroidism, PEM and terminal conditions, where death was expected within a few weeks.

The dietary record routine (paper I-III, V)

The record form is developed for use in clinical settings and is designed to be self-explanatory to the nursing staff. It consists of two A4 pages. The front page "Food and Fluid Chart" (Appendix A) is for individual dietary recording over a 24-hour period and the back page "Energy Contents Guide" (Appendix B) gives information about the energy content of some 100 food items common in hospital settings.

The development of the dietary record routine started in 1994 at a geriatric ward at an University Hospital in Sweden. The development started to get a clinical tool for nursing staff to be able to estimate the food intake of patients that were not eating well, and as a tool to evaluate actions taken to increase the dietary intake. At first other simple food and fluid charts were used. While using the charts the nurse assistants and the registered nurses at the ward were used as a reference group. When a number of food and fluid charts had been tested and found not suitable by the reference group, the development of the dietary record routine began. During 1994

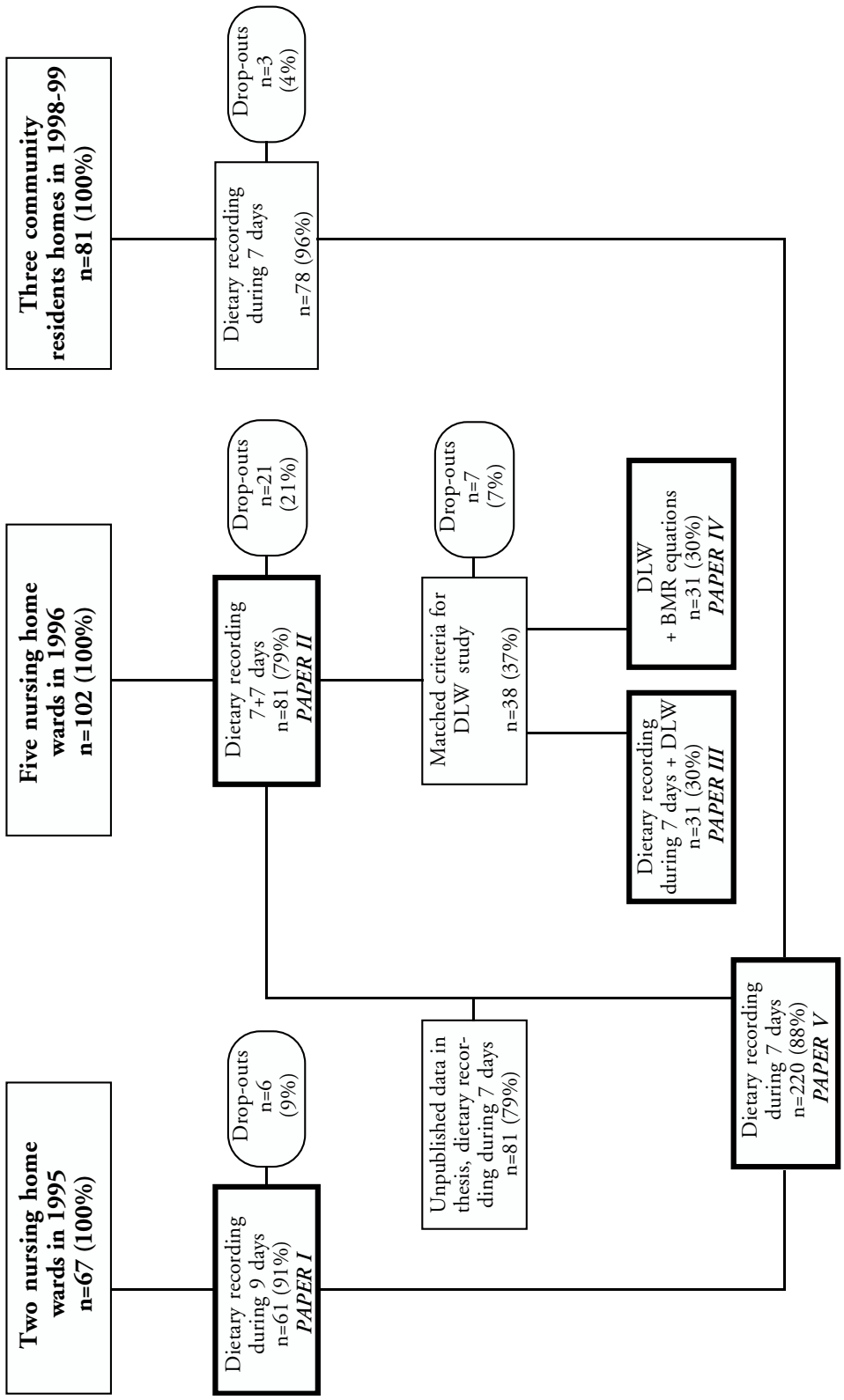

Figure 1. *A schedule of the participants in the different studies.*

and 1995 the dietary record routine was gradually developed in co-operation with the reference group and a clinical experienced dietian. During the development the dietary record routine were used to assess the energy and fluid intake of 18 geriatric patients at the ward. A total of 214 recorded days (median 8 days/patient) were used in the development. This data is not included here. Since the early testing was completed in 1995 the structure of the dietary record routine has not been changed, but minor improvements of the layout of the "Food and Fluid Chart" (see Appendix A) has been done.

All the patients eat and drink during a 24-hour day should be noted on the "Food and Fluid Chart", including snacks and items given by relatives. The food-intake at lunch and supper are described by standardised portion sizes using the quartile method (0, 1/4, 2/4, 3/4, 1/1). Breakfast, snacks, and beverages are assessed separately using household measuring devices. The energy content of each consumed food and fluid item is calculated using the "Energy Contents Guide". The total energy intake during a 24-hour period, usually from 07:00 to 07:00 the next day, is calculated by adding the energy content (kcal) of all consumed food and fluid items. The total fluid intake (mL) during the 24-hour day is also calculated.

Written instruction on how to use the dietary record routine has been developed. To help the nursing staff to estimate different portion sizes, the recommended portion sizes has been listed and photos of different portion sizes has been produced. The photos illustrated 1/1 and 1/2 portion sizes of breakfast (four pictures), lunch (six pictures) and supper (two pictures).

The "Energy Contents Guide" (see Appendix B) was developed during 1995 in co-operation with a clinical experienced dietian. The food and fluid charts were monitored to list frequently used food items in a hospital setting. The mean weight and/or volume of different food items and portion sizes were described by Swedish norms [167, 168] and the energy content by using Swedish food composition tables [169]. For some food items the weight and volume has been checked by the main author (MP) and a clinical experienced dietian. The "Energy Contents Guide" was not used in the study in May 1995, but was completed in 1996 before the recording began. Since 1996 the structure of the "Energy Contents Guide" has not been changed, although the list of local brand names of industrially made oral drinks have been updated during the years.

Nursing staff education (paper I-III, V)

Before the study period started the nursing staff attended an one-hour (1995 and 1998-1999; paper I and V) or a two-hour (1996; paper II and III) training session on taking dietary records. The training consisted of oral and written information on the dietary record routine and practical training in assessing portion sizes using both real dishes (all occasions) and photos (1996 and 1998-1999) of different dishes. During the study period, the nursing staff were provided with written information on the

recommended portion sizes (all occasions) and with photos (1996 and 1998-1999) of different portion sizes (see above).

During the study period of the reproducibility study (paper II) and validation study (paper III) the nursing staff received no direct assistance from the investigators other than having their questions answered. The record-keeping staff, which consisted of registered nurses, practical nurses and nurse assistants, were instructed not to alter any routines during the studies (paper II and III).

The recording was done in May 1995 (n=61) (paper I and V), between March and May (n=48) in 1996, between November and December (n=33) in 1996 (paper II, III and V), and between December 1998 and April 1999 (n=78) (paper V). No recording was done during any major holidays. The recording in 1995 was done during nine days, six weekdays and three weekend days (paper I), but in paper V only the first seven days are used and reportd (five weekdays and two weekend days). In 1996 the recording was done in two consecutive seven days periods with a median time gap of 21 days (range: 6-42 days) between the periods (paper II), but in paper V and in the unpublished data reported in this thesis, only the results from the first seven days period are used and reported. In the validation study (paper III) the dietary recording of the second seven day dietary recording period in 1996 was used (n=31). In 1998-1999 the recording was performed during seven consecutive days (paper V). In three patients the dietary recording were completed only in six days (four or five weekdays and one or two weekend days) and in one patient the recording were completed only in five days (three weekdays and two weekend days) (paper V). The total numbers of 24-hour days of recorded dietary intake included in this thesis are 2296.

Food handling (paper I-III, V)

In 1995 (paper I and V) and 1996 (paper II and III) the food was prepared by the hospital kitchen staff and served by the nursing staff. In 1998-1999 (paper V) the nursing staff served all meals and prepared breakfast and supper, while lunch was prepared in different ways. In two of three community residents homes the major food components of the lunches, such as meat/fish and sauce were delivered from a catering kitchen, while potatoes/rice/pasta, vegetables and desserts were prepared by the nursing staff. In one of the three community resident homes the nursing staff prepared the lunches during four days a week, while the other three days the lunches were delivered from a restaurant. Diets were classified as regular, pureed and liquid.

Recipes and nutrient calculation (paper I-III, V)

The recipes from all the different kitchens were collected and used to calculate the energy and nutrient content of each meal. Swedish norms for the mean weight and/or volume of different food items and portion sizes were used for consumed snacks and beverages [170, 171]. The utensils used at the wards were calibrated by volume.

About 350 different recipes of dishes have been used and calculated. The recipes have been checked and re-checked several times independently by different members of the research-team in order to avoid coding errors. Contact have been taken with the production kitchens several times, to code the right food items in the recipes and to get clarifications on the weight and/or volume of food items. The nutrient values for the recipes have been adjusted for losses of energy and water due to preparation and heating, but not for vitamin losses [172]. Such losses would affect vitamin C and to some extent thiamine, riboflavin and vitamin B6. The true intake of these nutrients are therefore probably lower than reported in this thesis.

The nutrient intake was calculated using a nutrient computer software program. In paper I: AIVOs Kostsvar, Stockholm, Sweden. In paper II and III: AIVO Kostplan 1.25, Stockholm, Sweden 1997 and Food Composition Table from Swedish PC-kost, December 1997, National Food Administration, Uppsala, Sweden. In paper V the nutrient intake was calculated using one and the same nutrient computer software program for all samples: AIVO Kostplan 2.20, Stockholm, Sweden 2000 and Food Composition Table from Swedish PC-kost, June 2000, National Food Administration, Uppsala, Sweden. Dietary records were coded by one of the investigators and then checked independently by another in order to avoid coding errors. The dietary intake of the patients in paper I was re-coded and re-calculated when the data was used in paper V.

In order to evaluate the "Energy Contents Guide" the energy intake was calculated concurrently using the "Energy Contents Guide" and a nutrient computer software program (AIVO Kostplan 1.25, Sweden 1997 and Food Composition Table from Swedish PC-kost, December 1997, National Food Administration, Uppsala, Sweden) in a subsample. The subsample consisted of the 81 patients recorded in 1996 and using the first seven day recording, in total 567 recorded 24-hour days.

Fluid intake was calculated from all consumed beverages. Water intake was calculated, using food composition tables, from the combined intake from fluids and food items. (paper II, III and V)

Metabolic water (paper III) was calculated using the equation 1.07 g water/g fat, 0.60 g water/g carbohydrate, and 0.41 g water/g protein [173].

Information on medication was retrieved from medical and nursing documentation (paper V). Vitamins and minerals given as medication have not been added to the estimated dietary intake of nutrients.

Mealtime habits (paper V)

The time of each meal and between-meal snack were registered in the dietary records. The overnight time period during which the patient was not served any food or beverages was calculated according to the notes from the dietary records. The 24-

hour day was divided into seven periods: breakfast (about 07:00-09:00), snacks in the morning (about 09:00-12:00), lunch (about 12:00-13:00), snacks in the afternoon (about 13:00-16:00), supper meal (about 16:00-18:00), snacks in the evening (about 18:00-21:00), and snacks during the night (21:00-07:00). The expression "daytime" is used for the period from 07:00 to 18:00. The expression "major meals" includes breakfast, lunch and supper, but no between-meal snacks.

The mealtime habits have been categorised using the FBCE tool to describe the dietary intake during each of the seven time periods during the 24-hour day [117]. The FBCE is a tool developed to categorise eating events [117]. The FBCE tool has been developed with Swedish "Food circle", the seven-food group system *(matcirkeln)* [174], as a base [175]. All food items and beverages consumed are classified according to seven food-groups. Every meal event is classified as "Complete Meal", "Incomplete Meal", Vegetarian Meal" or "Less Balanced Meal" according to which food-group items have been consumed. In the same concept the between-meal snacks is also classified as "High Quality Snack", "Low Quality Snack", "No Energy snack" or "Mixed Quality Snack". The amount of food eaten does not affect the classification. (See also Appendix 1 in paper V).

Dietary and energy requirements (paper V)

Dietary requirements have been calculated based on the Nordic Nutrition Recommendations 1996 (NNR96) [92] for recommended daily intake (RDI). Since the NNR96 have been compiled for healthy, free-living people, some adjustments had to be made to the recommended intake of macronutrients. In paper V energy requirements have been calculated based on Swedish recommendations for hospital nutrition [176, 177] using the equation of 33 kcal/kg BW minus 10% for age (since elderly people are less physically active). In the unpublished data (n=81) in comparing patients with and without PEM, energy requirements have been calculated based on Swedish recommendations for hospital nutrition [176, 177] by the equation of 33 kcal/kg BW minus 10% for age (since elderly people are less physical active) for ambulatory patients, and 29 kcal/kg BW minus 10% for age for bed-ridden patients. Protein requirements have been calculated based on the assumption that 15% of the mean total dietary energy should come from protein and that the corresponding figures for fat and carbohydrates should be 35% and 50%, respectively [176]. Dietary fibre requirements have been calculated to be 10 g/1000 kcal [178]. Vitamin A is given as retinol equivalents calculated from the intake of retinol plus one-sixth of the β-carotene intake [179]. Niacin is given as niacin equivalents. The term "minimum safety level" is the lower limit of intake recommended in the NNR96 since a "prolonged intake below these levels may induce a risk of deficiency" [92].

Total energy expenditure (paper III-IV)

The TEE of each patient was measured using DLW with the stable isotopes deuterium (^{2}H) and oxygen-18 (^{18}O) [125, 126]. The amount of isotope were calculated

for each individual according to TBW, which were measured by bioelectric impedance analysis (BIA) (see below). The isotopes were administered as a mixture of $^{2}H_{2}O$ and $H_{2}^{18}O$ with a calculated initial excess body water enrichment of 150 ppm for ^{2}H and 300 ppm for ^{18}O. Individual doses were stored in airtight screw-cap glass containers at +4°C. The isotopes were given orally in water. The patients drank approximately 75 to 100 mL, then the sample bottle was rinsed with approximately 50 mL of tap water, which also was consumed.

The isotopes were given in the evening, just before the patients went to bed. Before each dose was administered, a background blood sample was collected from the subject. The first blood sample was collected before breakfast after an overnight fast without any food or fluid intake. The mean equilibration interval, the time between isotope dosing and collection of the first blood sample, was 10.4 hours (SD ±0.8 hours; range 8.5 to 13.4 hours). The blood samples were taken by venipuncture using a vacuum system (Becton Dickinson sterile vacutainer® systems, Franklin Lakes, NJ, USA). Within half an hour after the sample was taken, the serum was separated by centrifuge for 10 minutes, then transferred to an airtight screw-cap glass container and immediately frozen to -20°C. A total of nine samples were taken from each patient: one sample before the dose, and one sample in the morning and one in the evening of days 1, 8, 15, and 22 of the study.

Sampling from the participants in DLW studies are often done from urine, however saliva, blood serum, or plasma have also been used [125, 126]. In a population of geriatric patients the prevalence of urine incontinence are usually high, with about 60% of the patients in Swedish nursing homes suffering from incontinence [180]. For this reason, there are practical problems associated with obtaining urine samples at specific time intervals as the study protocol demands [181]. In this context, we decided to perform this study with blood samples, even though the invasive method of venipuncture could be annoying to the patients.

The samples were analysed by isotope ratio mass spectrometry (Aqua Sira, VG Isogas Ltd Middlewich, Cheshire, UK). Administration and analyses of the samples followed the Maastricht protocol [181]. In the calculation of energy expenditure, the individual changes in BW during the study-period have been taken into account, i.e. if there were any changes in the body weight during the DLW sampling, the mean value of the body weight have been used to the calculation of TEE.

Water loss (paper III)

Water loss was estimated by ^{2}H dilution as part of the DLW measurements [181, 182]. The calculation of water loss has been described in detail by Westerterp [183].

Activities of daily life (paper II-IV)

Activities of daily life (ADL) have been classified using the Katz ADL Index [184-186].

Physical activity level (paper IV)

The PAL was estimated through a combination of direct structured observation during several days by the main author (MP), of interviewing the nursing staff who knew the patients well, and if possible, of interviewing the patients themselves. The patients' physical activity was measured and assessed on an 8-level scale (see Table 1). The PAR values used in this study were adopted from previous published studies on energy consumption [94, 187-189] and adjusted to fit the physical activity pattern of geriatric patients. The PAR value of the activity "sitting" was lowered to 1.3 since much of the sitting in geriatric patients is with low physical activity and the PAR value of the activity "standing" was lowered to 1.6 for the same reason. The PAR value of the activity "driving a wheelchair" was estimated to 3.0 based on other similar activities [94, 187-189] and the extra energy need in elderly [187, 189, 190]. The PAR value of the activity "walking" was raised to 4.0 since previous studies have indicated that some standard physical activities, especially walking, call for more energy in elderly than in younger persons [187, 189, 190].

Table 1. *Estimation of physical activity level (PAL) (paper IV). Adopted from [94, 187-189]. PAR = physical activity ration.*

Activity	*PAR value*
Sleeping (Lying in bed without any physical activity)	**1.0**
Resting in bed (Lying in bed but not sleeping, engaging in light activity, such as eating, reading, watching TV)	**1.2**
Sitting (Sitting without any activity or with light activities such as: reading, watching TV, eating)	**1.3**
Standing (Light standing activities, such as cooking, dishing)	**1.6**
Driving a wheelchair (Sitting in a wheelchair and driving it manually with the arm/s and/or leg/s)	**3.0**
Walking (Walking activities, such as walking by yourself, or cleaning)	**4.0**
Moderate activities (Physical activities, such as cleaning windows, cleaning, vacuum-cleaning, making the bed, gardening including digging, shovelling snow, cycling, fast walking)	**5.0**
Heavy activities (Heavy activities, such as physical training, physical exercises, ball games, running, dancing)	**6.0**

Basal metabolic rate equations (paper IV)

The BMR equations were compiled from references identified through a PubMed search and cross-referencing. The inclusion and exclusion criteria were determined from a clinical point of view, where the equation should be easy and practical to use on a daily basis. Inclusion criteria were that equations must be adopted for elderly women/men (>60 years of age) and predict BMR, resting metabolic rate (RMR), or TEE. Equations exclusively developed for, and/or tested in, younger people (<60 years) were excluded, as were equations developed for one gender only, and equations that use values of biochemistry analysis or anthropometric measurements other than BW and height. Equations using direct or indirect calorimetry were likewise excluded. According to these criteria eleven equations for calculation of BMR/RMR and two equations for calculation of TEE were identified. Some equations have been published in a simplified version, but in this study only the full length of the equations are used. Altogether, 13 equations were included (see Table 2), and descriptions of the different study populations and reference methods are given in Table 3.

Basal metabolic rate (paper I)

Basal metabolic rate was predicted using the equations given by FAO/WHO/UNU [94]. Energy expenditure was calculated assuming a physical activity level of 1.33 times BMR for both sexes, corresponding to a sedentary life for indoor subjects without daily physical activity. None of the included patients were bedridden.

Anthropometry (paper I-V)

Body weight (BW) was measured in the morning before breakfast, with the patients dressed in underwear or nightwear and without shoes (paper I-V). In paper I and V (1995 and 1998-1999 material) the BW was measured at an unspecified time during the dietary registration period. In the study 1996 (paper II, III, IV and V) the BW was measured three times; about four and two months before the study, and when the dietary recording began. In patients who took part in the DLW measurements (paper III and IV) the BW was also measured after the DLW sampling was finished and at a 3-months´ follow-up after the DLW study. Stature was measured, if possible, with the patients standing in an upright position without shoes [52], otherwise while lying in bed (paper II-IV). In a few cases, where present stature was not possible to measure accurately, a previously recorded value in medical or nursing documentation was used. Body mass index [53] and weight-index [54] were calculated using the measured BW and stature values (paper II-IV). Triceps skinfold thickness was measured at the midpoint of the back of the upper right arm with a Harpenden skinfold caliper [52]. At the same location mid-upper-arm circumference was measured and the arm muscle circumference calculated [52, 59] (paper II-IV).

Table 2. *Equations for estimating basal metabolic rate (E1-E10 and E13) and total energy expenditure (E11-E12). (paper IV)*

E1: ***Harris & Benedict*** (kcal/24h) [191]
Women: 665.0955 + 9.5634 x BW (kg) + 1.8496 x H (cm) - 4.6756 x age (y)
Men: 66.4730 + 13.7516 x BW (kg) + 5.0033 x H (cm) - 6.7550 x age (y)

E2: ***FAO/WHO/UNU*** (kcal/24h) [94]
Women >60 y: 9.2 x BW (kg) + 637 x H (m) - 302
Men >60 y: 8.8 x BW (kg) + 1128 x H (m) - 1071

E3: ***FAO/WHO/UNU*** (MJ/24h) [94]
Women >60 y: 0.0439 x BW (kg) + 2.49
Men >60 y: 0.0565 x BW (kg) + 2.04

E4: ***Schofield*** (MJ/24h) [192]
Women >60 y: 0.038 x BW (kg) + 2.755
Men >60 y: 0.049 x BW (kg) + 2.459

E5: ***Schofield*** (MJ/24h) [192]
Women >60 y: 0.033 x BW (kg) + 1.917 x H (m) + 0.074
Men >60 y: 0.038 x BW (kg) + 4.068 x H (m) - 3.491

E6: ***Schofield modified*** (MJ/24h) [193]
Women 60-74 y: 0.0386 x BW (kg) + 2.875
Women ≥75 y: 0.0410 x BW (kg) + 2.610
Men 60-74 y: 0.0499 x BW (kg) + 2.930
Men ≥75 y: 0.0350 x BW (kg) + 3.434

E7: ***Owen et al*** (kcal/24h) [194, 195]
Women: 795 + 7.18 x BW (kg)
Men: 879 + 10.2 x BW (kg)

E8: Mifflin-St Jeor equations (kcal/24h) [196]
Women: 9.99 x BW (kg) + 6.25 x height (cm) - 4.92 x age - 161
Men: 9.99 x BW (kg) + 6.25 x height (cm) - 4.92 x age + 5

E9: ***Fredrix et al*** (kcal/24h) [197]
Women: 1641 + 10.7 x BW (kg) - 9.0 x age (y) - 406
Men: 1641 + 10.7 x BW (kg) - 9.0 x age (y) - 203

E10: ***Westerterp et al*** [198]
Step 1. Fat-free mass (FFM) in kg
Women: -12.47 - 0.074 x age (y) + 27.392 x H (m) + 0.218 x BW (kg)
Men: -18.36 - 0.105 x age (y) + 34.009 x H (m) + 0.292 x BW (kg)
Step 2. Fat mass (FM) in kg
BW (kg) - FFM (kg)
Step 3. Basal metabolic rate (MJ/day)
0.102 x FFM (kg) + 0.024 x FM (kg) + 0.85

E11: ***Vinken et al*** (TEE MJ/24h) [199]
Women: 7.377 - 0.073 x age (y) + 0.0806 x BW (kg) + 0.0135 x H (cm) - 1.363
Men: 7.377 - 0.073 x age (y) + 0.0806 x BW (kg) + 0.0135 x H (cm)

E12: ***Poehlman & Dvorak*** (TEE MJ/24h) [200]
0.141 x BW (kg) - 0.720

E13: ***Lührmann et al*** (kJ/24h) [201]
Women: 3169 + 50.0 x BW (kg) - 15.3 x age (y)
Men: 3169 + 50.0 x BW (kg) - 15.3 x age (y) + 746

BW = body weight
H = Height
y = years

BMR/TEE expressed as kcal has been converted into MJ by multiplying with 0.004184.

Table 3. Background data for the equations of BMR (E1-E10) and TEE (E11-12) included in this study as presented in the original publications (paper IV).

Equation number	Publication year	*n*	Number of female (F) and male (M) participants	Mean age, years, SD (±), range	Mean body-weight in kg, SD (±)	Mean height in cm, SD (±)	Number of participants ≥60y	Methods used
E1	1919 (series I)	239	F 103 M 136	31 ±14 (15-74) 27 ±9 (16-63)	55.9 ±11.5 63.9 ±10.3	162.0 ±5.2 172.9 ±7.6	6 3	Indirect calorimetry
	1928 (series II)	60	F 33 M 27	32 ±12 (18-58) 34 ±16 (21-89)	63.4 ±12.0 71.5 ±20.3	161.4 ±6.0 173.5 ±8.1	0 3	
	1935 (Bangor series)	38	F 33 M 5	77 ±6 (66-88) 81 ±7 (74-87)	55.5 ±11.9 66.5 ±10.3	154.0 ±7.1 171.0 ±4.2	33 5	
E2 **E3**	1985	11937	F 4315 M 7622	all ages	*	*	* [1]	Meta analysis of 114 studies, mostly using indirect calorimetry
E4	1985	7173	F 2364	all ages	*	*	*	Meta analysis of different studies [5]
E5			M 4809	all ages	*	*	*	
			F 38 [2]	66 ±5 [4]	55.5 ±10.9	153.0 ±8.5	38	
			M 50 [3]	72 ±10 [4]	62.3 ±12.8	165.0 ±8.0	50	
E6	1991	>451	F >180	≥60	*	*	>180	Data on method not given [6]
			M >271	≥60	*	*	>271	
E7	1986	44	F 44	35 ±12 (18-65)	74.9 ±24.6	164.0 ±6.8	1	Indirect calorimetry
	1987	60	M 60	38 ±16 (18-82)	86.6 ±23.8	175.0 ±6.9	9	
E8	1990	498	F 247	44 ±14 (20-76)	70.2 ±14.1	164.2 ±6.3	*	Indirect calorimetry
			M 251	44 ±14 (19-76)	87.5 ±14.4	178.3 ±6.8	*	
E9	1990	40	F 22	66 ±7 (51-82) [7]	64.8 ±7.1	*	*	Indirect calorimetry
			M 18	63 ±8 (51-82) [7]	81.1 ±11.0	*	*	
E10	1995	190	F 105	42 ±20 (20-95)	62.0 ±16.0	163.0 ±8.0	*	DLW and other methods [8]
			M 85	41 ±19 (19-80)	80.0 ±24.0	177.0 ±8.0		
E11	1999	93	F 49, M 44	(18-81)	*	*	30	Indirect calorimetry, DLW, activity monitors, self reported activity
			F 10 [9]	74 ±4 (68-80)	58.5 ±9.9	155.3 ±4.7	10	
			M 20 [10]	68 ±6 (60-81)	78.3 ±12.9	176.4 ±5.8	20	
E12	2000	30	F 17, M 13	73 ±8 [3]	65 ±11.0	*	*	Indirect calorimetry, DLW
E13	2002	286	F 179	67.8 ±5.7	67.5 ±10.0	159.9 ±5.5	179	Indirect calorimetry.
			M 107	66.9 ±5.1	78.8 ±9.7	173.0 ±6.5	107	

** Data not given. [1] Out of the 114 studies 17 included people >60 years of age. [2] Women >60 y also included in the total number of women (n=2364). [3] Men >60 y also included in the total number of men (n=4809). [4] Age range not given. [5] An anothed bibliography has been published over studies used. [6] Based on Schofield 1985 (38 women and 50 men >60 y) with new unpublished data added (180 women and 271 men) and some of the original subjects excluded (number not given). [7] Age range not given sex specific. [8] A mathematical simulation model based on a meta analysis of 11 different studies using doubly labeled water and other techniques. [9] Women >60 y also included in the total number of women (n=49). [10] Men >60 y also included in the total number of men (n=44).*

Body composition (paper IV)

Body composition was estimated both with anthropometric measurements (BW, height, triceps skinfold and arm muscle circumference), BIA [202, 203], and with the DLW method [125, 126].

Bioelectric impedance analysis with a BIA-109 (RJL Systems, Detroit, MI, USA) was performed with the patient in a supine position and in according to the manufacturer's instructions. Body composition was calculated with measured resistance values using a computer software program provided by the manufacturer.

Total body water was measured by deuterium dilution as part of the DLW measurements [181-183]. Assuming a two-compartment model of FM and FFM, the FFM was calculated assuming a hydration factor of 73% for TBW.

Fever (paper IV)

During the study period, nursing charts were monitored for fluctuations in the patients' body temperature. We did not take any initiative to measure the patients' body temperature, but noted the body temperature recorded by nursing staff as part of the normal nursing care routine. Fever in this study is defined as a body temperature ≥37.8°C [204-206].

Blood samples (paper II-IV)

Blood samples were taken to measure albumin, prealbumin, haemoglobin, triiodothyronine, thyroid-stimulating hormone, prothrombin and orosomucoid by standard routines at the Division of Clinical Chemistry, Malmö University Hospital, Sweden.

Protein-energy malnutrition (paper II-IV)

Criteria for PEM were based on weight index, triceps skinfold, arm muscle circumference, and serum albumin and serum prealbumin levels. A low value for three or more variables were used as an indicator of PEM [54, 59] (see Table 4).

Ethics (paper I-V)

Each patient and/or a close relative gave an oral informed consent to the patient's participation in the studies. The studies collected in 1996 were approved by the Local Ethical Committee at Medical Faculty, Lund University, Sweden (LU 87-96).

Table 4. *Criteria for PEM and cut-off levels.*

Variables	Normal value	Low value
Weight index (%)	>80	≤80
Triceps skinfold (mm)		
women 70-79 years	>13	≤13
women >79 years	>10	≤10
men 70-79 years	>6	≤6
men >79 years	>6	≤6
Arm muscle circumference (cm)		
women 70-79 years	>19	≤19
women >79 years	>18	≤18
men 70-79 years	>22	≤22
men >79 years	>21	≤21
Serum albumin (g/L)	>36	≤36
Serum prealbumin (g/L)		
women	>0.18	≤0.18
men	>0.20	≤0.20

Cut-off points according to Swedish norms [54, 59].
A low value for three or more variables is an indicator of PEM.

Statistics (paper I-V)

All statistical analyses were performed using SPSS for Windows (SPSS Inc; Chicago, IL, USA; paper II: 9:th ed. 1999; paper III: 8:th ed. 1997; paper IV and V:10:th ed. 1999). Values are expressed as means and standard deviations (SD). Since samples were small and not normally distributed, nonparametric methods were used in paper II-V for analysing data [207]. Results were considered to be statistically significant if P-values were <0.05.

Paper I

Student's t-test was used to analyse differences between groups. Cox regression analyses were performed to examine differences in energy intake with survival time as dependent variable.

Paper II

In the sub-group analysis the variables age, length of stay and BMI were divided by the median value and the weight index was set at 80%, in accordance with the criteria for PEM. The relationship between periods 1 and 2 was examined using the two-tailed Spearman's rank correlation coefficient. The cross-classification by tertiles was examined using the chi square test and Kendall's Tau-b value. The sub-group analysis were examined using the two-tailed Mann-Whitney U-test. The Kruskal-Wallis test were used for the items ward and diagnosis.

Paper III

In the sub-group analysis the item weight index was set at 80%. The relationship between EI and EE, as well as between water intake and water loss, were examined using the two-tailed Spearman's rank correlation coefficient. The cross-classification by tertiles was examined using the chi square test and Kendall's Tau-b value. The sub-group analysis were examined using the two-tailed Mann-Whitney U-test. The Kruskal-Wallis test was used for the item diagnosis.

Paper IV

In the subgroup analysis the variables age and PAL were divided by the median value. The relationship between measured TEE and calculated EE were examined using two-tailed Spearman's Rank Correlation Coefficient and Root Mean Square Error (RMSE) [208]. Cross-classification by tertiles were examined using chi-squared test and Kendall's Tau-b value. The two-tailed Mann-Whitney U-test was used to explore differences between patients with and patients without fever.

Paper V

Differences in the dietary intake between women and men and between patients with an EI above and patients with an EI below calculated energy requirements were examined using the two-tailed Mann-Whitney U-test. Differences between the different recording years (1995, 1996 and 1998-1999), the different wards and age groups (<70, 70-79, 80-89 and >90 years of age), quartiles of overnight period without food, and quartiles of the number of meals, were examined using the Kruskal-Wallis test.

Unpublished data

The correlation between EI values calculated by "Energy Contents Guide" and computer-based nutrient calculation programme, were examined using two-tailed Spearman's Rank Correlation Coefficient. Differences in dietary intake between patients with and without PEM were examined using the two-tailed Mann-Whitney U-test.

Results

Paper I - 6-months survival

Out of 67 geriatric patients 61 patients (43 women and 18 men) with a mean age of 87 years (SD ±8 years; range 56-103 years) were included in the study. Six patients were excluded; one patient died during the diet assessment period, one patient was discharged from the ward and four patients with unstable medical conditions.

Eighty-four percent of the 61 patients had an EI below estimated calculated energy expenditure, and 35% of the women and 17% of the men had an EI below calculated BMR (see Table 5).

Table 5. *Mean daily energy intake, calculated energy expenditure and energy balance. Values are given as mean values, SD and range (paper I).*

	Women (*n*=43)	**Men** (*n*=18)
Energy intake (kcal)	1280 ±307 (185-1962)	1557 ±230 (1142-1957)
Calculated energy expenditure (kcal)	1607 ±200 (1312-2215)	1790 ±269 (1540-2742)
Energy balance (kcal)	-327 ±367 (-1670 -- +188)	-232 ±240 (-786 -- +163)

Table 6 shows that the eleven patients who died during the 6-months follow-up had significantly lower energy and protein intake and a higher negative energy balance compared to those alive six months later. None of the deceased used dietary supplements. The diagnoses of these patients were; dementia, seven patients; cancer three patients and cerebrovascular disease in one patient. The proportion of dementia disorders and cerebrovascular disease did not differ between the groups, but three (27%) of the deceased had a cancer diagnosis compared to two (4%) among the alive patients (chi square test P=0.05). However, if these five patients with a diagnosis of cancer were excluded from analyses, the above mentioned differences with lower EI and negative energy balance among deceased remained (1130 kcal vs. 1384 kcal; P< 0.05; and -270 kcal vs. -589 kcal; P<0.05, Student's test). A logistic regression analysis with respect to an EI below median (1378 kcal) were associated with an increased 6-months mortality risk, OR=12.5 (CI 90% 1.9 – 71.4) adjusted for age and cancer.

A Cox regression analyses with survival time as dependent variable and log-transformed EI as the independent variable, adjusted for age, cancer (yes/no) and dementia (yes/no) showed that higher EI was related to a decreased risk of death; RR=0.06 (95% confidence interval: 0.01- to 0.56).

Table 6. *Intake of energy and nutrients and calculated energy expenditure in patients who were deceased or alive 6 months after the dietary assessment (paper I). Students test with P-values. Values are given as mean value, SD (±) and range.*

	Deceased (*n*=11)	**Alive** (*n*=50)	***P*-value**
Energy intake (kcal)	1185 ±380 (185-1537)	1401 ±284 (642-1962)	0.04
Protein (g)	48.1 ±17.7 (10.4-76.7)	57.8 ±14.1 (19.2-91.8)	0.05
Fat (g)	37.3 ±15.9 (3.1-64.3)	44.1 ±17.1 (17.7-138.1)	0.23
Carbohydrates (g)	149.3 ±45.2 (29.2-196.6)	173.4 ±36.5 (87.2-247.0)	0.06
Vitamin D (µg)	2.9 ±2.1 (0.3-7.3)	2.4 ±1.0 (0.3-5.6)	0.25
Thiamin (mg)	0.8 ±0.4 (0.2-1.3)	1.0 ±0.3 (0.4-2.2)	0.07
Vitamin B12 (µg)	1.6 ±0.8 (0.1-2.7)	2.1 ±0.9 (0.2-4.0)	0.11
Vitamin C (mg)	66.1 ±23.0 (23.8-104.1)	54.4 ±24.2 (18.1-133.2)	0.15
Calcium (mg)	771.8 ±305.4 (270.6-1225.2)	818.9 ±231.1 (120.1-1317.4)	0.57
Iron (mg)	7.4 ±3.0 (2.2-11.0)	8.5 ±2.4 (2.4-13.7)	0.18
Calculated energy expenditure (kcal)	1687 ±212 (1312-2039)	1655 ±242 (1335-2742)	0.70
Energy balance (kcal)	-502 ±536 (-1670 -- +188)	-254 ±261 (-1050 -- +182)	0.03
Body weight (kg)	60.8 ±11.8 (37.0-77.5)	57.5 ±13.9 (38.3-102.0)	0.47
Age (years)	87 ±6 (75-97)	86 ±8 (56-103)	0.68

Paper II - Reproducibility of the diet record routine

Population

One hundred and two patients from the wards matched the study criteria and agreed to participate. However, data were not obtained for 21 (13 women and 8 men) of the 102 patients: 13 were excluded before or during the diet recording due to acute illness and eight patients died before any diet recording was done. Thus, the study group consisted of 81 patients (56 women and 25 men) with a mean age of 85 years (SD ±7.8 years; range 58-97 years). The mean length of stay was 752 days (SD ±612 days; range 66-2871 days). The most common diagnoses were dementia 33%, stroke 27%, orthopaedic disorders 10%, neurological disorders 7% and cancer 4%. Most of the patients had multiple medical diagnoses; 38% had dementia and 31% had stroke among their multiple diagnoses. Sixty-eight percent of the patients scored a F or G on the Katz ADL Index, indicating that they were highly dependent on others in their activities of daily life (ADL). Twenty one percent of the patients were dependent for all activities. Only 10% of the patients were highly independent, as indicated by scores of A or B (see Table 7). Of the 81 patients 58% had a BMI between 20 and 30, 38% below 20 and only 4% had a BMI above 30. Anthropometric values are given in Table 8.

Diets

Out of the 81 patients, 73% were given a regular diet, while 27% were given pureed foods. Only 3% of the patients received food supplements on a daily basis and 12% of the patients received food supplements at some time during the study period. Of the 81 patients 28% met the criteria for PEM.

Table 7. *Katz ADL index of patients (n=81) participating in the reproducibility study (paper II).*

Katz ADL index	**Number of patients**
A	3 (4%)
B	5 (6%)
C	5 (6%)
D	2 (3%)
E	11 (14%)
F	38 (47%)
G	17 (21%)

Table 8. *Anthropometric and biochemical measurements of patients (n=81) participating in the reproducibility study (paper II). Values are given as mean value, SD (±) and range.*

	Women (*n*=56)	**Men** (n=25)
Body weight (kg)	52.6 ±9.4 (35.5-76.1)	66.9 ±11.7 (43.0-97.5)
Stature (m)	1.57 ±0.09 (1.27-1.75)	1.71 ±0.04 (1.63-1.80)
BMI	21.5 ±4.1 (14.8-32.4)	23.0 ±4.6 (15.8-35.4)
Weight index (%)	80.5 ±14.1 (55.5-120.7)	87.3 ±17.2 (59.7-133.6)
Mid arm circumference (cm)	24.6 ±3.4 (15.0-32.9)	26.8 ±3.2 (20.6-34.8)
Triceps skinfold (mm)	11.8 ±4.0 (5.4-21.2)	9.4 ±2.7 (5.4-16.1)
Arm muscle circumference (cm)	20.9 ±2.7 (11.4-27.0)	23.8 ±2.7 (17.6-30.4)
Haemoglobin (B-Hb) (g/L)	128 ±14 (101-153)	134 ±11 (110-153)
Plasma orosomucoid (g/L)	1.06 ±0.28 (0.67-2.01)	1.03 ±0.21 (0.60-1.49)
Plasma prothrombin (P-PT) (%)	93 ±23 (10-111)	96 ±9 (61-100)
Serum albumin (g/L)	37 ±4 (28-46)	38 ±3 (33-43)
Serum prealbumin (g/L)	0.23 ±0.06 (0.12-0.40)	0.23 ±0.06 (0.15-0.39)
Serum thyroid-stimulating hormone (S-TSH) (mIU/L)	1.3 ±0.9 (0.1-4.0)	1.4 ±0.7 (0.1-2.8)
Serum triiodothyronine (S-T3) (nmol/L)	1.3 ±0.3 (0.8-2.0)	1.2 ±0.3 (0.5-1.8)

Energy and nutrients

The mean daily EI during the first registration period was 7.07 MJ (SD ±1.40 MJ) and 6.84 MJ (SD ±1.32 MJ) during the second period, with a mean difference of 4%. The corresponding values for the periods for women were 6.70 MJ (SD ±1.28 MJ) versus 6.43 MJ (SD ±1.24 MJ) with a mean difference of 5%, and for men 7.89 MJ (SD ±1.32 MJ) versus 7.77 MJ (SD ±0.99 MJ) with a mean difference of 2%. Data for other nutrients are given in Table 9. Spearman's correlation coefficients between measurements varied for most nutrients between 0.7 to 0.9 for women and between 0.6 and 0.9 for men (see Table 9). Individual values of the daily mean EI during the two periods are given in Figure 2.

Table 9. *Dietary intake in the reproducibility study (paper II) during period 1 and 2 for women and men separately. Values are given as daily mean intake and SD (±). Spearman's correlation coefficients (r) are given and p-values are given as *=p<0.05, **=p<0.01 and ***=p<0.001.*

	Women (*n*=56)			**Men** (*n*=25)		
	Period 1	**Period 2**	*r*	**Period 1**	**Period 2**	*r*
Energy (kcal)	1601 ±305	1537 ±295	0.83 ***	1885 ±316	1857 ±237	0.61 **
Energy (MJ)	6.7 ±1.3	6.4 ±1.2	0.83 ***	7.9 ±1.3	7.8 ±1.0	0.61 ***
Protein (g)	59.2 ±14.5	57.3 ±13.3	0.83 ***	71.0 ±14.5	69.3 ±11.5	0.68 ***
Fat (g)	54.0 ±13.5	51.8 ±12.6	0.85 ***	63.3 ±12.6	63.1 ±11.5	0.68 ***
Carbohydrates (g)	214.3 ±41.2	205.4 ±43.5	0.83 ***	247.6 ±41.6	243.8 ±30.4	0.51 **
Alcohol (g)	1.8 ±3.0	1.7 ±2.7	0.92 ***	4.3 ±4.1	3.8 ±4.0	0.89 ***
Dietary fiber (g)	11.9 ±2.9	11.4 ±3.2	0.84 ***	15.2 ±3.9	15.1 ±3.2	0.55 **
Vitamin A (µg)[1]	841.9 ±401.0	736.0 ±267.9	0.71 ***	878.3 ±404.9	819.9 ±237.1	0.42 *
Vitamin D (µg)	2.5 ±1.2	2.3 ±1.0	0.89 ***	3.2 ±1.0	3.0 ±1.0	0.75 ***
Thiamin (mg)	1.2 ±0.3	1.2 ±0.3	0.78 ***	1.4 ±0.4	1.4 ±0.3	0.85 ***
Riboflavin (mg)	1.5 ±0.4	1.4 ±0.3	0.84 ***	1.7 ±0.4	1.7 ±0.4	0.80 ***
Niacin (mg)[2]	23.4 ±6.2	22.3 ±5.5	0.77 ***	29.0 ±6.3	28.2 ±5.6	0.66 ***
Vitamin B6 (mg)	1.3 ±0.3	1.3 ±0.4	0.80 ***	1.7 ±0.4	1.7 ±0.4	0.59 **
Folate (µg)	163.6 ±57.7	148.1 ±49.3	0.82 ***	191.1 ±65.6	181.6 ±51.3	0.70 ***
Vitamin C (mg)	77.0 ±52.6	71.3 ±50.2	0.82 ***	80.8 ±56.3	75.7 ±51.2	0.87 ***
Calcium (mg)	1018 ±254	996 ±256	0.89 ***	1109 ±270	1094 ±242	0.83 ***
Iron (mg)	6.1 ±1.8	5.8 ±1.7	0.78 ***	7.5 ±1.8	7.4 ±1.6	0.44 *
Water (mL)	1702 ±291	1631 ±273	0.81 ***	1958 ±362	1925 ±290	0.67 ***
Fluid (mL)	1246 ±276	1179 ±266	0.84 ***	1263 ±266	1228 ±232	0.72 ***

[1] *Vitamin A is given in retional equivalents.* [2] *Niacin is given in niacin equivalents.*

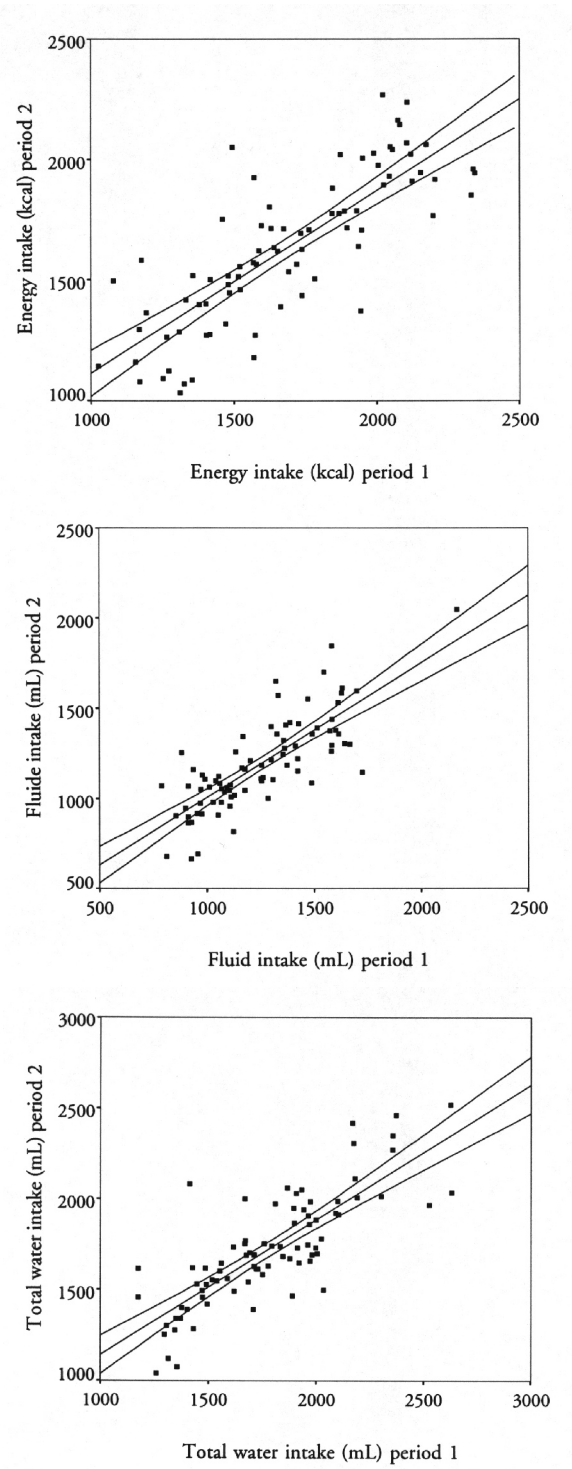

Figure 2. *Individual values of energy, fluid and water intake in the reproducibility study (paper II) in period 1 and 2. The lines indicate mean value and the 95% CI interval.*

The difference between EI during the first and the second period (ΔE) and the relative difference (ΔE%) were examined in relation to gender, age, length of stay, diagnosis, body weight, weight index, diet, ADL independence, PEM and nursing home ward. Statistically significant differences were only noted for weight index, BMI and nursing home ward. Energy intake in relation to reduced eating ability, defined as Katz index level G (21 %), did not differ between periods. Cross-classification of EI

Table 10. *Cross-classification of energy intake (mean kcal/day), fluid intake (mean mL/day) and water intake from food and beverages (mean mL/day) by tertiles during period 1 and 2 (n=81) (paper II).*

Energy intake (kcal) period 2

		1034-1498	1499-1784	1785-2270	Total
Energy intake	1027-1502	21 (78%)	5 (18%)	1 (4%)	27
(kcal) period 1	1503-1882	5 (18%)	18 (67%)	4 (15%)	27
	1883-2344	1 (4%)	4 (15%)	22 (81%)	27
	Total	27	27	27	81

Fluid intake (mL) period 2

		667-1071	1072-1289	1290-2051	Total
Fluid intake	791-1086	19 (70%)	8 (30%)	0	27
(mL) period 1	1087-1366	8 (30%)	13 (48%)	6 (22%)	27
	1367-2169	0	6 (22%)	21 (78%)	27
	Total	27	27	27	81

Water intake (mL) period 2

		1042-1605	1606-1833	1834-2520	Total
Water intake	1176-1619	21 (78%)	5 (18%)	1 (4%)	27
(mL) period 1	1620-1928	5 (18%)	16 (59%)	6 (22%)	27
	1929-2632	1 (4%)	6 (22%)	20 (74%)	27
	Total	27	27	27	81

during period 1 compared to period 2 by tertiles shows that 75% of the patients were classified correctly and only 2% were grossly misclassified by more than one tertile (see Table 10) and Kendall's tau-value was 0.72.

Water and fluid

The mean daily WI from food and beverages was 1781 mL (SD ±334 mL) during the first period compared to 1702 mL (SD ±291 mL) during the second period with a mean difference of 4%. The relative differences between the periods were 5% for women and 2% for men. The mean daily FI was 1251 mL (SD ±272 mL) during the first period compared to 1194 mL (SD ±256 mL) during the second period with a mean difference of 6%. Individual values of the daily mean WI and FI during the two periods are given in Figure 2.

The difference between daily WI during the first and the second period (ΔW) and the relative difference (ΔW%) were examined in relation to gender, age, length of stay, diagnosis, body weight, diet, ADL independence, PEM and nursing home ward. Statistically significant differences were only noted for weight index, PEM and nursing home ward. Cross-classification of daily water intake during period 1 compared to period 2 by tertiles shows that 70% of the patients were classified correctly and only 2% were grossly misclassified by more than one tertile (Table 10) and Kendall's Tau-b value was 0.67.

Corresponding analyses of FI between periods showed no significant differences in relation to the above mentioned factors except for nursing home wards. The mean daily FI per kg BW were 23 mL during period 1 and 22 mL during period 2 corresponding to a 1.1 mL difference/kg BW between the periods. Similar daily mean FI was noted for men and women ranging from 1179 to 1263 mL between the periods. Cross-classification of FI during period 1 compared to period 2 by tertiles shows that 65% of the patients were classified correctly and none was grossly missclassified by more than one tertile and Kendall's Tau-b value was 0.68 (see Table 10).

Paper III - Validity of the diet record routine

Population

Out of 102 patients, 37 matched the study criteria and agreed to participate in the study. Data are not available on six of the 37 patients, as three patients after inclusion declined further participation in the study, it was impossible to get the required blood-samples in two patients and in one patient there was no enrichment of the DLW, probably due to a not properly consumed dose. Consequently, the study group consisted of 31 patients (18 women and 13 men) with a mean age of 86 years (see Table 11). The mean length of time the patients had spent at the wards was 709 days (SD ±531 days; range 73 to 2346 days). The most common main diagnoses were

Table 11. *Age, body height and weight, body fat mass (FM), fat free mass (FFM) and total body water (TBW) measured with doubly labelled water (DLW) and bioimpedance (BIA), mean values, SD (±) and range (paper III and IV).*

Variables	Women (*n*=18)	Men (*n*=13)	All (*n*=31)
Age	87.5 ±6.0	82.9 ±7.3	85.6 ±6.8
range	71-96	65-92	65-96
Body height, cm	157.3 ±6.8	170.0 ±3.7	162.7 ±8.5
range	149.0-175.0	163.0-175.0	149.0-175.0
Body weight, kg	55.8 ±9.1	69.8 ±8.1	61.7 ±11.1
range	45.0-74.8	56.0-85.5	45.0-85.5
FM, kg (DLW)	20.0 ±6.0	23.7 ±5.9	21.5 ±6.1
range	11.5-30.5	15.5-37.6	11.5-37.6
FM, kg (BIA)	24.4 ±8.2	26.2 ±9.8	25.1 ±8.8
range	14.5-40.3	9.0-41.2	9.0-41.2
FM, % (DLW)	35.4 ±6.0	33.5 ±5.3	34.6 ±5.7
range	24.0-44.4	25.9-44.2	24.0-44.4
FM, % (BIA)	43.3 ±8.6	36.4 ±11.1	40.4 ±10.2
range	30.9-58.6	16.5-49.4	16.5-58.6
Mean differences FM, DLW- BIA (kg)	-4.3 ±3.9	-2.5 ±4.9	-3.6 ±4.4
FFM, kg (DLW)	35.7 ±4.7	46.4 ±4.2	40.2 ±6.9
range	29.0-45.7	38.2-52.3	29.0-52.3
FFM, kg (BIA)	30.9 ±4.4	44.1 ±4.8	36.4 ±8.0
range	24.2-40.2	35.1-51.8	24.2-51.8
Mean differences FFM, DLW- BIA (kg)	4.8 ±3.8	2.2 ±4.7	3.7 ±4.3
TBW, kg (DLW)	26.1 ±3.4	33.8 ±3.1	29.3 ±5.1
range	21.2-33.4	27.9-38.2	21.2-38.1
TBW, kg (BIA)	22.6 ±3.2	32.3 ±3.5	26.7 ±5.9
range	17.7-29.4	25.7-37.9	17.7-37.9
Mean differences TBW, DLW- BIA (kg)	3.5 ±2.8	1.6 ±3.5	2.7 ±3.2

dementia (n=11), stroke (n=7), neurological disorders (n=3), orthopaedic disorders (n=3) and others (n=7). According to the Katz ADL index, the participants were highly dependent on others in ADL, as indicated by a score of F or G for 18 out of the 31 patients, five patients of whom were dependent in all activities. Only four patients were highly independent, as indicated by scores of A or B. The remaining nine patients had Katz ADL index scores of C or E. The mean BW was 55.8 kg for women and 69.8 kg for men (see Table 11). Mean BMI was 22.6 for women and 24.2 for men. Out of the 31 patients 26 had a BMI between 20 and 30 whereas five had a BMI <20 and none had a BMI >30. The mean change in BW during the study was -0.5 kg (SD ±1.9 kg; SEM 0.4 kg; n=29). Body weight for two patients were missing at the end of the study, as one patient died and another was relocated after the DLW sampling was finished and before BW was measured again.

Energy intake and total energy expenditure

The mean EI was 7.2 MJ/day (SD ±1.3); 6.7 MJ/day (SD ±1.4) for women and 7.9 MJ/day (SD ±0.9) for men. The mean DLW-measured TEE was 6.7 MJ/day (SD ±1.4), 6.1 MJ/day (SD ±1.1) for women and 7.5 MJ/day (SD ±1.3) for men. Using the 7-day dietary record routine, the staff overestimated the mean EI by 8.4% when compared to DLW-measured TEE (see Table 12). The Spearman's rank cor-

Table 12. *Mean energy intake (EI) vs. DLW-estimated total energy expenditure (TEE). Values are given as mean, SD (±), range and confidence interval (CI) (paper III).*

	Women (*n*=18)	**Men** (*n*=13)	**All** (*n*=31)
Energy intake			
Kcal	1607 ±324	1892 ±204	1727 ±311
95% CI	1446-1768	1769-2015	1613-1841
range	1124-2165	1496-2239	1124-2239
Energy expenditure			
Kcal	1453 ±272	1791 ±317	1595 ±333
95% CI	1318-1588	1600-1983	1473-1717
range	1009-2079	1255-2290	1090-2290
EI overestimation compared with TEE (%)	+10.1	+5.6	+8.4
Spearman's rank correlation coefficents			
between EI and TEE	0.78	0.80	0.81
Mean difference between EI and TEE			
Kcal	+154 ±213	+101 ±193	+132 ±203
95% CI	48-- 260	-16-- +218	57-- 207
range	-293 -- +470	-246 -- +551	-293 -- +551

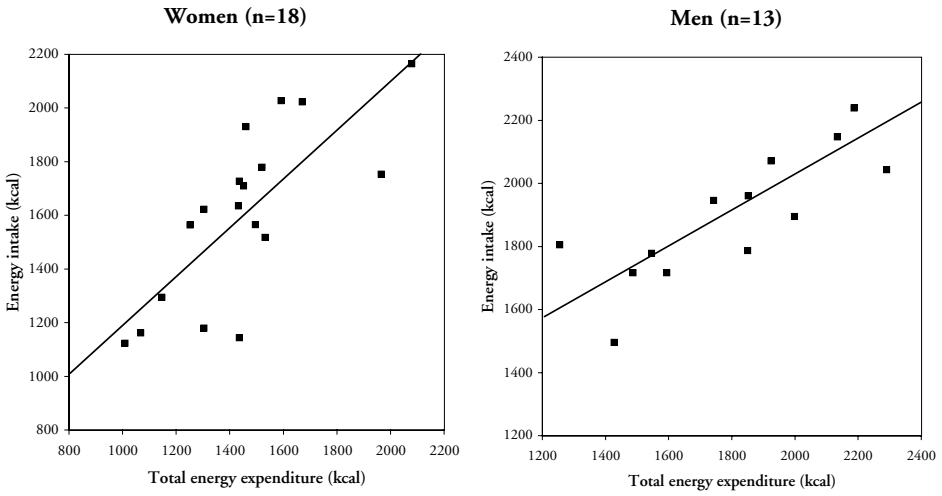

Figure 3. *Individual values of DLW measured TEE and energy intake in women and men separately (paper III).*

relation coefficients between EI and DLW-measured TEE was 0.81 (P<0.001), 0.78 (P<0.001) for women and 0.80 (P=0.001) for men. Individual values of the daily mean EI and the mean DLW-measured TEE are given in Figure 3.

The difference between EI and DLW-measured TEE (ΔE=EI-EE) and the relative difference (ΔE%) were examined in relation to gender, age, body weight, ADL independence, eating ability and diagnoses. No statistically significant differences between ΔE and ΔE% were noted for age, ADL independence vs. dependence, or independence vs. total dependence during mealtime corresponding to a score of G on the Katz ADL index. Statistically significant differences were found between gender groups, body-weight groups, and diagnoses. Cross-classification of EI compared to DLW-measured TEE by tertiles showed that 68% of the patients were classified correctly and none was grossly misclassified by more than one tertile (see Table 13) and Kendall's Tau-b value was 0.69.

Water

Mean WI was 1787 mL/day (SD ±263); 1697 mL/day (SD ±211) for women and 1911 mL/day (SD ±285) for men. Labelled water estimated mean water loss was 1774 mL/day (SD ±368); 1673 mL/day (SD ±286) for women and 1914 mL/day (SD ±285) for men. Using the 7-day dietary record routine, the staff overestimated mean WI from food and beverages by 0.7% when compared to water loss. The Spearman's rank correlation coefficients for the difference between WI and water loss was 0.82 (P<0.001): 0.77 (P<0.001) for women and 0.79 (P<0.01) for men.

The difference between WI and water loss (ΔW=WI-WL) and the relative differ-

Table 13. *Cross-classification of energy intake (mean kcal/day) and DLW-estimated total energy expenditure, and of water intake and labelled water estimated water loss, by tertiles (n=31) (paper III).*

		Total energy expenditure estimated by DLW (kcal)		
		1009 - 1436	1437 - 1695	1696 - 2290
Energy intake	1124 - 1631	8	2	0
(kcal)	1632 - 1907	2	6	3
	1908 - 2239	0	3	7

		Labeled water estimated water loss (mL)		
		1070-1607	1608-1887	1888-2580
Water intake	1123-1639	6	4	0
(mL)	1640-1893	4	5	2
	1894-2464	0	2	8

ence (ΔW%) were examined in relation to gender, age, body weight, ADL independence, eating ability, and diagnoses. Statistically significant differences were found between body-weight groups and ADL-independence/dependence groups. Cross-classification of water intake compared to water loss by tertiles showed that 61% of the patients were classified correctly and none was grossly misclassified by more than one tertile (see Table 13) and Kendall's Tau-b value was 0.63. No differences in the cross-classification were found when metabolic water oxidation was taken into account. No evidence of dehydration, defined by haemoglobin of 113 to 153 g/L for women and 122 to 166 g/L for men, was found.

Paper IV – Basal metabolic rate equations

Population

A description of the population is given in the results of paper III - se above.

Measured total energy expenditure

The mean TEE of the patients, according to DLW measurements, was 6.67 MJ (SD ±1.39 MJ; range 4.22-9.58 MJ), 6.08 MJ (SD ± 1.14; range 4.22-8.70 MJ) in women, and 7.49 MJ (SD ±1.33 MJ; range 5.25-9.58 MJ) in men. Mean TEE/kg BW in the patients was 26.0 kcal (SD ±3.7 kcal; range 19.0-33.6 kcal), 26.2 kcal (SD±3.7 kcal; range 21.1-33.6 kcal) in women, and 25.7 kcal (SD ±3.8 kcal; range 19.1-31.4 kcal) in men.

Physical activity

The mean estimated PAL of the patients was 1.20 (SD ±0.12; range 1.01-1.41), 1.22 (SD ±0.12; range 1.09-1.41) in women, and 1.18 (SD ±0.12; range 1.01-1.40) in men. The range of the day-to-day variation in the patients' physical activity was small. The patients' activities were mainly sleeping, resting in bed, and sitting. No patient took part in any moderate or heavy activities and no patient was receiving any regular physical rehabilitation or training. Only one of the patients took part in normal daily activities at the wards, such as setting the table for dinner or doing the dishes. Out of the 31 patients, 13 were dependent on a wheelchair for getting about, eight of which were able to drive the wheelchair by themselves. Only three of the patients could walk by themselves without any technical or personal aid, while nine patients were able to walk with a rollator and two patients with the assistance of nursing staff. Out of the 31 patients, four were bedridden most of the time and only got out of bed for a few hours each week.

Calculated total energy expenditure

The eleven equations used for prediction of BMR in combination with estimated PAL and the two equations used for predicting TEE were compared with DLW-measured TEE. The 13 equations (see Table 2) were compared with mean TEE

Table 14. *Mean calculated energy expenditure with the different equations including measured PAL compared with DLW measured TEE as reference in all patients (n=31) (paper IV).*

	Mean and SD (±) (MJ/24h)	Range (MJ/24h)	Mean difference E1-E13 and TEE (MJ/24h)	Range difference (MJ/24h)	Difference (%) E1-E13 and TEE	RMSE* (MJ)	Spearman's correlation coefficents E1-E13 and TEE *P*=<0.01
E1	5.92 ±0-95	4.55-8.41	-0.75	-2.68 -- +0.54	-12.7	1.06	0.88
E2	6.61 ±0.95	5.07-9.07	-0.07	-2.39 -- +1.30	-1.0	0.77	0.87
E3	6.24 ±0.90	5.03-8.40	-0.43	-2.75 -- +1.21	-6.9	0.94	0.80
E4	6.36 ±1.00	5.01-8.93	-0.31	-2.35 -- +1.21	-4.9	0.82	0.83
E5	6.49 ±0.97	5.01-9.04	-0.19	-2.39 -- +1.14	-2.9	0.79	0.86
E6	6.40 ±0.95	5.00-8.72	-0.27	-2.40 -- +1.20	-4.2	0.78	0.87
E7	6.83 ±1.23	5.01-9.92	+0.16	-1.44 -- +1.56	+2.3	0.77	0.83
E8	5.61 ±1.21	5.22-8.45	-1.06	-2.63 -- +0.41	-18.9	1.31	0.85
E9	6.07 ±1.23	3.85-8.90	-0.61	-2.06 -- +0.65	-10.0	0.94	0.86
E10	6.77 ±1.17	4.11-9.74	+0.10	-1.69 -- +1.38	+1.4	0.71	0.86
E11	7.51 ±1.69	5.00-9.99	+0.83	-1.32 -- +3.53	+12.5	1.54	0.70
E12	7.98 ±1.56	5.62-11.34	+1.31	-0.70 -- +3.34	+19.6	1.72	0.70
E13	6.29 ±1.21	4.56-9.14	-0.38	-1.77 -- +0.78	-6.1	0.77	0.86
TEE	6.67 ±1.39	4.22-9.58					

* Root mean square error

results for the whole group (see Table 14) and separately for women and men. The equations were also compared with a subgroup analysis of low and high PAL with a cut-off at PAL 1.2 as well as low and high age, with a cut-off at 86 years. Seven (E2, E4, E5, E6, E7, E10, E13) out of the 13 tested equations, in combination with estimated PAL, managed to predict TEE within a ±10% range in all of the analyses and four of these (E2, E5, E7, E10) could predict TEE within a range of ±5%. The three equations in combination with estimated PAL that best predicted TEE for both women and men with high and low PAL and high and low age were: E10 [198], E2 [94] using both BW and height, and E7 [194, 195] using only BW.

Cross-tabulation by tertiles of the three best predictive equations showed that E7 [194, 195] classified 74% of the patients correctly, eight out of eleven were correctly classified in the lowest tertile and nine out of ten were correctly classified in the highest tertile. None was misclassified by more than one tertile and Kendall's Tau-b value was 0.75. When using cross-tabulation by tertiles, the other two equations E10 [198] and E2 [94], classified 68% of the patients correctly. Seven out of eleven were correctly classified in the lowest tertile, and nine out of ten were correctly classified in the highest tertile. No patient was misclassified by more than one tertile, and Kendall's Tau-b value was 0.69.

Body weight

The 3-months follow-up after the DLW study showed no statistical difference in BW changes between the patients with a low PAL (<1.2) and those with a high PAL (≥1.2). Both groups gained BW during the two months before and three months after the DLW measurements (mean total time = 165 days). The group with a low PAL (n=13) had a mean weight gain of +1.0 kg and the group with a high PAL had a mean weight gain of + 0.1 kg (n=14). Follow-up data on four patients are missing due to the patients' death, illness, or relocation.

Fever

During the time period of DLW measuring, four patients had a nursing chart recording of fever. In three out of the four patients, the fever lasted for a maximum of two days and one patient had a temperature for a total of six days. In none of the patients did the body temperature exceed 39.0°C. Mean DLW-measured TEE was 6.70 MJ in patients without fever and 6.47 MJ in patients with a fever. There was no statistically significant difference between patients with and patients without a fever in either measured or calculated TEE. However, there was a significant difference in estimated PAL ($P<0.05$), with a mean PAL in patients with fever of 1.10 and in patients without fever of 1.22.

Paper V - Mealtime habits

Population

Out of 250 patients, 220 met the inclusion criteria and agreed to participate in the study. Thus, the study group consisted of 220 patients (164 women and 56 men) with a mean age of 86 years (SD ±7.7 years; range 55-103 years). Out of the total number of patients the participation rate for 1995 was 91% (n=61), for 1996 79% (n=81), and 1998-1999 96% (n=78). In 30 patients (19 women and 11 men) with a mean age of 87 years (SD ± 8.1 years; range 87-102 years) data were not obtained, due to eight patients died before any diet recording was done, three patients died during the recording, two patients was discharged from the ward and 17 patients were excluded due to acute illness.

Dietary intake

The mean daily EI was 6.44 MJ (SD ±1.44 MJ; range 1.44-11.93 MJ) in women and 7.38 MJ (SD ±1.53; range 4.52-12.56 MJ) in men (see Table 15). Data for specific nutrients are given in Table 15. Mean daily EI/kg BW was 29.4 kcal (SD ±7.7 kcal; range 8.6-50.5 kcal) in women and 26.4 kcal (SD ±6.6 kcal; range 16.2-54.1 kcal) in men (see Table 16). A comparison between EI values over the years 1995-1999 showed that there was an increase in intake for women in crude values; however, when converting this to EI/kg BW it was found that the EI was the highest in 1996. In men the EI in crude values was lowest in 1995; however, when converting this to

Table 15. *Dietary intake and Nordic Nutrition Recommendations (NNR96) for recommended dietary intake (RDI) levels in women and men (paper V). Values are given as mean daily intake, SD (±) and range. Values given in brackets in the columns with RDI correspond to minimum safety-level.*

	Women (*n*=164)			**Men** (*n*=56)		
	Dietary intake	RDI for women >75 years and minimum safety-level	Below RDI and minimum safety-level (%)	Dietary intake	RDI for men >75 years and minimum safety-level	Below RDI and minimum safety-level (%)
Energy (MJ)	6.44 ±1.44 (1.44-11.93)	6.71[1]	57	7.38 ±1.53 (4.52-12.56)	8.50[1]	77
Protein (g)	56.3 ±14.0 (15.4-91.2)	60	66	65.4 ±15.3 (36.8-103.0)	76	71
Fat (g)	54.5 ±16.3 (5.2-103.0)	62	71	59.3 ±15.4 (33.3-115.0)	79	89
Carbohydrates (g)	202.8 ±48.9 (58.0-427.0)	200	53	234.7 ±48.2 (141.0-385.0)	254	61
Alcohol (g)	0.9 ±2.1 (0.0-12.8)	-		3.6 ±4.1 (0.0-15.1)	-	
Dietary fibre (g)	11.0 ±3.2 (0.5-21.7)	16	90	13.5 ±4.0 (5.1-22.5)	20	93
Vitamin A (µg)	748.2 ±385.6 (128.2-2740.5)	800.0 (600.0)	57 (35)	825.4 ±465.1 (231.5-2780.8)	900.0 (600.0)	68 (21)
Vitamin D (µg)	2.9 ±1.4 (0.4-6.9)	10.0 (2.5)	100 (41)	3.2 ±1.1 (1.6-6.3)	10.0 (2.5)	100 (23)
Vitamin E (mg)	5.2 ±2.3 (1.1-22.2)	8.0 (3.0)	90 (10)	5.9 ±2.4 (3.2-18.2)	10.0 (4.0)	91 (11)
Thiamine (mg)	1.0 ±0.3 (0.3-2.2)	1.0 (0.5)	43 (1)	1.3 ±0.4 (0.6-2.8)	1.1 (0.6)	34 (2)
Riboflavin (mg)	1.4 ±0.4 (0.4-2.7)	1.2 (0.8)	27 (2)	1.6 ±0.5 (0.7-3.6)	1.3 (0.8)	23 (4)
Niacin (mg)	21.2 ±5.5 (7.0-37.4)	13.0 (9.0)	4 (1)	26.1 ±6.6 (12.2-48.5)	15.0 (11)	4 (0)
Vitamin B6 (mg)	1.2 ±0.3 (0.5-2.6)	1.1 (0.9)	35 (10)	1.5 ±0.4 (0.6-2.7)	1.2 (1.0)	14 (11)
Folate (µg)	151.5 ±51.0 (55.4-353.0)	300.0 (100)	98 (11)	173.6 ±57.8 (93.8-356.0)	300.0 (100)	95 (2)
Vitamin B12 (µg)	3.8 ±1.3 (1.0-11.8)	2.0 (1.0)	4 (0)	4.3 ±1.4 (1.9-9.9)	2.0 (1.0)	2 (0)
Vitamin C (mg)	74.6 ±45.2 (19.7-329.0)	60.0 (10.0)	49 (0)	80.3 ±46.2 (14.3-250.0)	60.0 (10.0)	38 (0)
Calcium (mg)	947.6 ±269.1 (323.0-1828.0)	800.0 (400.0)	33 (1)	1014.8 ±269.7 (495.0-1564.0)	800.0 (400.0)	23 (0)
Iron (mg)	6.4 ±2.3 (2.6-16.7)	10.0 -	94 -	7.5 ±2.3 (3.7-14.3)	10.0 (7.0)	89 (41)
Zinc (mg)	7.9 ±2.1 (2.5-14.7)	7.0 (4.0)	33 (2)	9.2 ±2.4 (4.8-14.0)	9.0 (5.0)	45 (2)
Selenium (µg)	25.2 ±8.1 (2.0-56.2)	40.0 (20.0)	96 (23)	29.0 ±8.5 (8.8-57.2)	50.0 (20.0)	98 (13)

[1] *Energy requirements were calculated as 33 kcal/kg BW minus 10% for elderly people with a reduced physical activity. Conversions from kcal to MJ were done by multiplying the kcal value by 0.004184. The given value is mean value for the women and men separately and corresponds to an estimated individual dietary recommendation and not to NNR96.*

Table 16. *Energy intake (EI), fluid intake (FI), and water intake (WI) calculated from diets and during different time periods (paper V). Daytime was defined as 07:00 to 18:00. Values are given as mean daily intake, SD (±), and range. P-values using Mann Whitneys U-test are given as *=P<0.05, **=P<0.01, ***=P<0.001.*

	Women (*n*=164)	**Men** (*n*=56)		**All** (*n*=220)
EI (kcal)	1540 ±343 (343-2852)	1759 ±369 (1080-3001)	***	1596 ±362 (343-3001)
EI/kg BW (kcal)	29.4 ±7.7 (8.6-50.5)	26.4 ±6.6 (16.2-54.1)	**	28.6 ±7.5 (8.6-54.1)
EI during daytime (%)	97 ±4 (74-100)	97 ±4 (83-100)		97 ±4 (74-100)
EI during the evening and at night (%)	3 ±4 (0-26)	3 ±4 (0-17)		3 ±4 (0-26)
EI from major meals (%)	87 ±7 (62-100)	86 ±5 (70-95)		87 ±6 (62-100)
EI from between-meal snacks (%)	13 ±7 (0-38)	14 ±5 (5-30)		13 ±6 (0-38)
FI (mL)	1163 ±299 (414-2236)	1266 ±286 (791-1934)	*	1189 ±298 (414-2236)
FI/kg BW (mL)	22.3 ±7.4 (9.9-56.6)	19.1 ±5.7 (9.3-38.2)	**	21.5 ±7.1 (9.3-56.6)
FI during daytime (%)	93 ±7 (72-100)	92 ±7 (68-100)		93 ±7 (68-100)
FI during the evening and at night (%)	7 ±7 (0-28)	8 ±7 (0-32)		7 ±7 (0-32)
FI from major meals (%)	74 ±10 (39-94)	73 ±10 (43-91)		74 ±10 (39-94)
FI from between-meal snacks (%)	26 ±10 (6-61)	27 ±10 (9-57)		26 ±10 (6-61)
WI (mL)	1589 ±337 (342-2902)	1863 ±335 (1140-2630)	***	1659 ±357 (342-2902)
WI/kg BW (mL)	30.4 ±8.5 (8.6-73.5)	28.2 ±7.5 (17.9-58.8)		29.9 ±8.3 (8.6-73.5)
WI during daytime (%)	95 ±5 (77-100)	95 ±5 (75-100)		95 ±5 (75-100)
WI during the evening and at night (%)	5 ±5 (0-23)	5 ±5 (0-25)		5 ±5 (0-25)
WI from major meals (%)	81 ±8 (53-96)	81 ±8 (55-94)		81 ±8 (53-96)
WI from between-meal snacks (%)	20 ±8 (4-47)	19 ±8 (6-45)		19 ±7 (4-47)

EI/kg BW it was found that the EI was the lowest in 1998-1999. There was a large difference in mean daily EI/kg BW between the different wards ranging from 24.3 kcal to 36.2 kcal and the proportion of patients who had a sufficient EI, according to calculated energy requirements, ranged from 19-65%. Out of the 220 participants 62% had an insufficient EI, according to calculated energy requirement. Altogether 57% of the women and 77% of the men had an EI below calculated energy requirements (see Table 15). The proportions of patients who had an inappropriate intake of the nutrients varied from 2% to 100% (see Table 15). Energy intake/kg BW, FI/kg BW, WI/kg BW and percentage of patients with an insufficient EI did not differ significantly between age groups and types of diet.

The mean number of meals/day (intake of food and/or fluids in any of the periods) was 4.7 (SD ±0.7; range 2.4-6.9). The mean values between the different wards ranged from 4.4 to 5.7 meals/day. There was a significant difference (P=0.02) between patients with an EI above and patients with an EI below the calculated energy requirements. Patients with an EI above calculated energy requirements had a mean value of 4.9 meals/day, while the corresponding value for patients with an EI below the calculated energy requirements was 4.6 meals/day. Patients with many meals/day had a higher EI than did patients with fewer meals/day. The quartile of patients (n=59) with the highest number of meals/day (5.0-6.9) had a mean daily EI of 1803 kcal (SD ±351 kcal; range 1156-2852 kcal). The corresponding value in the quartile (n=59) with the fewest meals/day (2.4-4.1) was 1512 kcal (SD ±390 kcal; range 343-3001 kcal) (P<0.001). The variation in mean EI/day, mean FI/day and mean WI/day between the days of the week appear to be random. There was a slight increase in EI during the weekend days compared with weekdays; however, this was not statistically significant.

The mean daily FI was 1163 mL (SD ±299 mL; range 414-2236 mL) in women and 1266 mL (SD ±286 mL; range 791-1934 mL) in men (see Table 16). The mean daily FI/kg BW was 22.3 mL (SD ±7.4 mL; range 9.9-56.6 mL) in women and 19.1 mL (SD ±5.7; range 9.3-38.2 mL) in men (see Table 16). The range of mean values of FI/kg BW between the different wards was 16.9-27.1 mL.

The mean daily WI was 1589 mL (SD ±337 mL; range 342-2902 mL) in women and 1863 mL (SD ±335 mL; range 1140-2630 mL) in men (see Table 16). The mean daily WI/kg BW was 30.4 mL (SD ±8.5 mL; range 8.6-73.5 mL) in women and 28.2 mL (SD ±7.5 mL; range 17.9-58.8 mL) in men (see Table 16). The range of mean values of WI/kg BW between the different wards was 24.0-37.5 mL.

Almost all (97%) of the EI occurred within about 9 hours (usually from about 08:00 to 17:00) during daytime and 87% came from the major meals (i.e. breakfast, lunch and supper). Corresponding values of fluid intake were 93% (within 10 hours, usually from about 08:00 to 18:00) and 74%, respectively (see Table 16). Patients with an EI below calculated energy requirements had a lower proportion of EI (12% vs. 15%; P=0.04) and FI (25% vs. 28%; P=0.04) from between-meal snacks than did patients with an EI above calculated energy requirements. The diurnal variations of

EI between wards, expressed as %EI from between-meal snacks, varied from 11% to 19% (P<0.001). Corresponding values for FI were 22% to 34% (P<0.001).
The mean overnight period without any food was 15.2 hours and statistical differences (P<0.001) were found between the different wards. The range of mean values of overnight period without any food between wards was 14.8-15.7 hours, and the range of mean values between individuals was 11.5-16.9 hours. The mean overnight period without any intakes of beverages was 13.9 hours and there were statistical differences (P<0.001) between the different wards. The range of mean values for the overnight period without intakes of beverages between wards was 12.5-14.7 hours, and the range of corresponding mean values between individuals was 7.2-16.8 hours. There was a significant difference (P<0.001) in the EI between patients who had a shorter compared with a longer overnight period without food intake. The quartile of patients (n=54) with the shortest overnight period without food intake (of 11.5-14.9 hours) had a mean daily EI of 1769 kcal (SD ±319 kcal; range 1166-2852 kcal). The corresponding value in the quartile (n=55) with the longest period without food intake (i.e. 15.7-16.9 hours) was 1482 kcal (SD ±286 kcal; range 878-2330 kcal).

According to the FBCE tool classification in the study population, lunch usually could be classified as "complete meals" and "prepared meals". In 1996 and 1998-99 the supper meals could usually be classified as "complete meals" and "prepared meals" with the exception of some meals which had porridge as the main dish. By contrast, in 1995 many of the supper meals were classified as "incomplete meals". Breakfast was usually classified as an "incomplete meal" and "quick prepared meal". In general, here were only a few patients who did not have an intake from all major meals, while there was greater variation in the frequency of intake from "between-meal snacks". Most of the patients had coffee and cake, classified as "low-quality snacks", in the afternoon. The period after supper until breakfast the next morning was often without any intake of food and with only a little fluid. Statistical differences were found using the FBCE tool between the different study years and the different wards, and between patients with an EI above and patients with an EI below the calculated energy requirements. Patients with an EI below the calculated energy requirements had fewer "complete meals", more "incomplete meals", fewer "prepared meals", more "quick prepared meals", as well as more instances of no intake between meals.

Dietary supplements

Out of the 220 patients only 7% received dietary supplements (liquid dietary supplements or food fortification) on a daily basis and 15% of the patients received dietary supplements at sometime during the dietary registration. Information on medication was retrieved from 144 subjects, 23% of whom took vitamin and/or mineral supplementation with their medication.

Re-coding and re-classification

The dietary intake of the patients in paper I (n=61) was re-coded and re-calculated using the one and same database for all patients in paper V (n=220) to make a comparison between the different study years possible. The re-coding and the newer database had the consequence that almost all of the nutrients reported in paper V was higher than the values reported in paper I (see Table 17).

Table 17. *Reported dietary intake in paper I and paper V in women and men separately. The original reported intake from paper I has been re-coded and re-calculated using the one and same database in paper V for reasons of comparison. Values are given as mean daily intake, SD (±) and range.*

	Women (*n*=43)		**Men** (*n*=18)	
	Reported intake paper I	**Reported intake paper V**	**Reported intake paper I**	**Reported intake paper V**
Energy (kcal)	1280 ±307 (185-1962)	1361 ±316 (343-2113)	1557 ±230 (1142-1957)	1632 ±218 (1341-1996)
Protein (g)	53.1 ±15.5 (10.4-91.8)	54.2 ±15.5 (15.4-87.1)	62.9 ±12.0 (39.9-82.6)	62.8 ±10.4 (48.4-79.8)
Fat (g)	41.1 ±19.3 (3.1-138.1)	42.9 ±12.0 (5.2-67.5)	47.1 ±8.6 (36.0-65.3)	50.4 ±9.2 (33.3-65.0)
Carbohydrates (g)	160.1 ±40.0 (29.2-243.8)	187.0 ±42.9 (58.0-316.0)	190.7 ±30.0 (123.8-247.0)	227.5 ±30.7 (169.0-276.0)
Thiamin (mg)	0.9 ±0.3 (0.2-1.5)	1.0 ±0.3 (0.3-1.9)	1.2 ±0.4 (0.6-2.2)	1.2 ±0.2 (0.9-1.8)
Vitamin B12 (µg)	2.0 ±0.9 (0.1-4.0)	3.6 ±1.2 (1.0-6.3)	2.0 ±0.9 (0.3-3.6)	3.9 ±1.0 (2.2-6.8)
Vitamin C (mg)	53.1 ±25.2 (18.1-133.2)	72.9 ±39.5 (29.8-185.0)	64.7 ±19.9 (45.6-124.2)	72.8 ±26.7 (42.0-136.0)
Vitamin D (µg)	2.4 ±1.4 (0.3-7.3)	2.5 ±1.3 (0.7-6.9)	2.6 ±1.1 (1.1-5.6)	2.9 ±1.0 (1.6-6.0)
Calcium (mg)	806.1 ±251.9 (120.1-1317.4)	958.8 ±316.2 (323.0-1828.0)	820.6 ±230.4 (410.4-1262.3)	979.7 ±251.9 (495.0-1380.0)
Iron (mg)	7.9 ±2.6 (2.2-13.7)	5.9 ±2.4 (2.6-16.7)	9.5 ±1.7 (6.3-12.1)	7.1 ±2.0 (5.0-13.0)

Unpublished data

Population

A description of the population is given in the results of paper II - se above.

Protein energy malnutrition

Out of the 81 patients 41 (51%) had an insufficient EI, according to calculated energy requirements (see Table 18). Statistical differences in EI were found between patients with an EI above and patients with an EI below calculated energy requirements (see Table 18). Patients with an EI above the calculated energy requirements (n=40) had a daily mean energy surplus of 343 kcal and an EI kg/BW of 36.6 kcal. Residents with an EI below the calculated energy requirements (n=41) had a daily mean energy deficit of 309 kcal and an EI kg/BW of 24.6 kcal.

Out of the 81 patients 23 (28%) met the criteria for PEM (se Table 4). There were statistical differences in EI between patients classified with and patients classified with-out PEM (see Table 18). Patients without PEM had an EI of 28.4 kcal/kg BW. The corresponding value in patients with PEM was 35.9 kcal/kg BW. Only 5 out of 41 patients with an EI below the calculated energy requirements were also classified as having PEM.

Table 18. *Comparisons of mean daily energy intake (EI) and mean daily energy requirements (ER) in crude values and in EI/kg bodyweight (BW). Values are given as mean values and P-values are given as: * = P<0.05, ** = P<0.01, *** = P<0.001.*

		Mean EI (kcal)	**Mean ER (kcal)**	**Mean EI-ER difference** (kcal)	**Mean EI/kg BW** (kcal)	**Mean BW** (kg)
Women	EI above ER	1741 ***	1414 ***	+326 ***	36.6 ***	47.8 ***
(*n*=56)	(*n*=32; 57%)					
	EI below ER	1411	1729	-318	24.1	59.1
	(*n*=24; 43%)					
Men	EI above ER	2098 *	1688 *	+410 ***	36.7 ***	58.3 **
(*n*=25)	(*n*=8; 32%)					
	EI below ER	1783	2080	-297	25.2	71.0
	(*n*=17; 68%)					
All	EI above ER	1812 **	1469 ***	+343 ***	36.6 ***	49.9 ***
(*n*=81)	(*n*=40; 49%)					
	EI below ER	1565	1874	-309	24.6	64.0
	(*n*=41; 51%)					
No PEM	(*n*=58; 72%)	1709	1802 ***	-93 **	28.4 ***	61.4 ***
PEM	(*n*=23; 28%)	1632	1351	+281	35.9	45.9

Calibration of "Energy Contents Guide"

A calibration between EI calculated with the nutrient computer software program (AIVO Kostplan 2.20, Stockholm, Sweden 2000 and Food Composition Table from Swedish PC-kost, June 2000, National Food Administration, Uppsala, Sweden) and a manual calorie-count using the "Energy Contents Guide" (see Appendix B) in a 7-day dietary intake recording (567 24-hours recorded days) with "Food and Fluid Chart" (see Appendix A) in 81 geriatric patients showed a mean difference of 18 kcal and a Spearman's correlation coefficient of 0.995 (see table 19).

Table 19. *Calibration between energy intake (EI) calculated with computer based nutrient software program and manual calorie-count using the "Energy Contents Guide" using a 7-day dietary intake and a total of 567 24-hours recorded days. Mean values, SD (±) and range.*

	EI (kcal) computer program	**EI (kcal) "Energy Contents Guide"**	**Difference (kcal)**	**Spearman's correlation coefficient *P*<0.01**
Women (*n*=56)	1599 ±304 (1028-2200)	1582 ±308 (1014-2174)	18 ±36 (-39 -- +111)	0.993
Men (*n*=25)	1884 ±316 (1080-2344)	1865 ±308 (1089-2321)	19 ±36 (-43 -- +103)	0.991
All (*n*=81)	1687 ±333 (1028-2344)	1669 ±333 (1014-2321)	18 ±36 (-43 -- +111)	0.995

Discussion and conclusions

Population

When comparing the participants in the reproducibility study (paper II) with the official Swedish statistics of people living in nursing homes and in sheltered housing for the elderly [209] and with a national survey of 407 nursing homes in Sweden [210], the participants had the same distribution with regard to sex and almost the same distribution with respect to diagnosis, functional dependence as measured by Katz ADL Index and age. Some differences were noted, with a longer length of stay in nursing homes in the study group and with more patients over the age of 90 years, but otherwise the distributions were similar. Also, the proportion of patients with PEM (28%) corresponds to that reported by the Swedish National Board of Health and Welfare [5].

Even if the participants in the studies that took place in 1996 and reported in this thesis on the whole might be representative with the elderly in nursing homes and sheltered housing at that time, the care dependency of geriatric patients admitted to nursing homes and sheltered housing has increased over the past 10 years [158-160]. So the participants in the studies reported in this thesis are not fully comparable with the population at the long-stay ward that existed in Sweden before the Social Act in 1992 ("Ädel-reform"), when responsibility for the care of the elderly in sheltered housing and nursing homes was transfered fron county to municipality, and we could also expect changes in the future.

The BW in the general population has been increased during the past decades [54, 211]. Comparing the study-group in 1996 and 1998-1999 some differences are noted. In 1998-1999 the body weight and BMI had increased in both women and

Table 20. *Anthropometric measurements of patients (n=78) from three community home wards 1998-1999 (paper V). Values are given as mean value, SD (±) and range.*

	Women (*n*=65)	**Men** (n=13)
Body weight (kg)	57.2 ±12.2 (31.5-102.0)	71.8 ±12.0 (51.5-96.0)
Stature (m)	1.59 ±0.07 (1.45-1.74)	1.73 ±0.08 (1.55-1.81)
BMI	22.7 ±4.3 (15.0-40.4)	24.2 ±4.1 (17.4-30.9)
Weight index (%)	86.0 ±16.4 (55.3-152.2)	92.0 ±15.4 (66.0-116.2)

men (see Tables 8 and 20) compared to 1996. More of the patients in 1998-1999 were not quit dependable as in 1996 when comparing Katz ADL-index (see Tables 7 and 21).

Table 21. *Katz ADL index in patients (n=78) from three community home wards 1998-1999 (paper V).*

Katz ADL index	**Number of patients**
A	4 (5%)
B	20 (26%)
C	9 (12%)
D	7 (9%)
E	8 (10%)
F	16 (21%)
G	12 (15%)
O	2 (3%)

The patients in the DLW study (paper III and IV) were generally healthier than many geriatric nursing home patients, due to the inclusion criteria of stable body weight and exclusion criteria of diseases or conditions that could affect their energy metabolism. It is thereby also probable that the patients (n=31) who took part in the DLW study had a higher mean EI at a group level compared to all Swedish nursing home patients.

Dietary record routine

The dietary record routine have been developed and used in almost 2300 patient days reported in this thesis. Recording of fluid intake is a well-known routine in hospitals and the dietary record routine is built on the same principle. The new routine is a recording also of the food intake and a calorie count. The recording and monitoring should be done by the nursing staff. However, it is important to involve both patient and relatives, if possible, in the recording. It is also of great importance to involve all of the nursing staff on the wards, especially also the staff on the night shift, to get accurate recordings.

Reproducibility of dietary record routine

Numerous studies have used dietary records to validate 24-hour recalls, diet history and food frequency charts. A satisfactory method of estimating dietary intake must be repeatable, but few studies have been published on the reproducibility of food

records and those have mostly been done with weight records and self-estimated food records for free-living younger people. Edington et al [121] found a correlation value of 0.86 in EI when studying the repeatability of a 7-day estimated record in free-living adults. Jørgensen et al [122] also found a good reproducibility of a 7-day estimated food record and Toeller et al [123] of a 3-day estimated record. Reproducibility studies with estimated dietary records in clinical settings were the nursing staff has done the dietary assessing and recording, have not previously been published.

In order to test the reproducibility of a dietary record routine, the subjects' dietary intake should be stable over time and the circumstances during the two measuring periods should be the same [97]. However, even in the stable situation of a nursing home ward where all meals are supplied by the same hospital kitchen, it is unlikely that patients are offered the same dishes and eat and drink exactly the same amount during the two seven day periods. Thus, some of the differences noted may reflect true differences in intake.

The time gap between periods 1 and 2 in the reproducibility study (paper II), was a deliberate attempt to eliminate bias introduced by learning effects among the recording nursing staff. A gap of 4-8 weeks has been recommended between recording periods [212]. In similar reproducibility studies the time gap has been between 3 and 8 weeks [121-123]. It is possible that the medical and physical condition of some patients may have changed over this interval, and such changes may be reflected in their dietary intake.

The menus offered by the hospital kitchen cycle through a five-week rotation with several serving alternatives available for every meal, it was not possible to ensure that all aspects of the situation were identical for both measurement periods. This was particularly the case because of the concern that the nursing staff should not change any routines during the reproducibility study (paper II), other than filling in the dietary records. This concern reflects the desire to conduct this study in a clinical setting, given that the dietary record routine is intended to be used clinically.

Given these constraints, the mean differences in the reproducibility study (paper II) of 4% in energy and water intake and 6% in fluid intake between the two periods indicates the stability of this dietary assessment method.

The patients who dropped out of reproducibility study (paper II) generally did so during the start-up period before dietary recording began. The main reasons for dropping out were death and illness. The fact that some patients dropped out may have had some effect on the mean dietary intake, since some of the patients who died probably had a lower intake prior to recording due to terminal decline. Thus, the results obtained from repeated assessment of a group may be slightly higher in this study, than in other cross-sectional studies of nursing home patients with only one assessment period.

The lower correlation coefficient values in reproducibility study (paper II) obtained for men in general may to some extent be explained by the narrower distribution of men compared to women in this study and by the larger portion sizes eaten by the men, as indicated by the higher EI. The lower correlation coefficients for vitamin A and iron in men may be due to sporadic intake of liver, rich in vitamin A, during one of the periods.

Estimated dietary recording by nursing staff in clinical settings and using the quartile method has been shown to correlate very well with the weight of food consumed in a Swedish study [213], but in a study in long-term-care in USA the accuracy was lower [214]. However the hospital catering system was not the same in the two studies and cultural differences may also have an effect. Since the nursing staff served almost all food and beverages on the wards and since the same calibrated utensils were used when serving the food, this will reduce systematic error due to conditions of patients and sampling data. A weighed diet record is not a better option in a clinical setting where the nursing staff are doing the recording for several patients at one time. Even though a weighed dietary record may more accurately assess the amount of food eaten and the food waste, the method takes longer time to carry out and may entail a higher risk of changed dietary intake due to the recording itself. However, the estimated dietary record is ultimately superior as a dietary recording routine intended to be used by nursing staff in a clinical setting.

The precision of the dietary record routine was in the reproducibility study (paper II) not influenced by diagnosis, type of diet or use of supplements, function as defined by Katz ADL index, age, gender or length of stay at the ward. This is especially important if the method is being used to identify persons at risk of developing malnutrition. A difference between periods was noted for patients with low body weight as indicated by weight index and BMI. This group of patients probably has the most frail elderly, and consequently a more fluctuating dietary intake. All but 2 of the 23 patients classified as having PEM were in the group with a BMI below the median. It is, of course, also possible that some of the patients with suspected energy malnutrition had clinically undetected conditions. Significant differences were found between the different nursing home wards, which may indicate that the method is affected by the nursing staff's interest in performing the study and the different routines at the wards, such as how the nursing care was organised and the routines during mealtimes.

Validity of dietary record routine

Although studies have been published on the validity of assessment of healthy elderly people's EI [215], this seem to be the first study to use DLW as a means of validating energy and fluid intake information recorded in a dietary record routine among institutionalised geriatric patients. To ensure the reliability of this comparison, consideration was taken to the fact that various types of medical conditions can change metabolism and absorption, or cause excessive nutritional losses. Furthermore the

fact that dietary intake can be impaired by psychiatric disorders and functional incapacity caused by movement disorders or swallowing problems have to be considered [7, 9]. Hospitalisation, the patients' mealtime situation, the numbers of the nursing staff present during mealtimes, eating facilities, and ambience can affect food intake [9]. Sidenvall [216] showed that skills and values of staff highly affected mealtimes and the quality of individual patient care. For these reasons, the patients selected to take part of the validity study (paper III) was geriatric patients who had no diseases or conditions that could affect their energy metabolism: patients who had a stable body weight, normal body temperature, and no evidence of acute illness.

In a number of studies, higher EI values have been reported by investigators using dietary history method compared to 7-day dietary record [217]. Most of these diet history studies have demonstrated reliability, but not validity, due to the lack of an existing "golden standard". Furthermore, the EI indicated by dietary records tend to be lower than the energy expenditure determined in studies based on DLW or calculated energy expenditure [218]. However, in a study by Prentice [219], the EI measured with a 7-day weighted dietary records overestimated the TEE measured with DLW in 14 geriatric patients. Similar findings were noted for children when their intake were reported by their parents [220]. In general underestimation seems to be more frequent than overestimation [221, 222]. In the validity study (paper III) it was noted an overestimation of EI using the dietary record routine. One possible explanation for this consistent finding may lie in a systematic over-reporting by the nursing staff. It is also possible that standardised portion sizes overestimate consumed amounts. In the validity study (paper III), the high correlation ($r=0.81$) between estimated EI and DLW-measured TEE could in part be explained by fewer errors in the food intake being made by the nursing staff, who also functioned as independent observers and thus, minimised the risk of patients altering self-reported dietary habits.

The difference between food-record reported EI and DLW-measured energy expenditure seems to be statistically insignificant with respect to age, ADL-independency/dependency, and independency vs. total depend during mealtime. There was a slight difference by gender, with a greater overestimate made for women. This difference may indicate that the staff believe that female patients eat more than they actually do. However, this difference disappeared when the EI was related to body weight or TEE. The difference was quite striking for patients with stroke compared with patients who had not had a stroke. The differences in EI and DLW-measured TEE may be due to differences in body weight as well as diagnosis. Six out of the seven patients with stroke had lower body weights, as indicated by BMI and weight index. Patients with a history of stroke were also more dependent for ADL functions. The differences for patients with a history of stroke may also be explained by communication problems and/or lack of sufficient attention from the staff.

Values for WI estimated by the dietary record routine and water loss estimated by labelled water estimated were close. The mean WI from food and beverages was

1787 mL and the mean water loss was 1774 mL. Using the DLW method, 60% of the patients were correctly classified in the lowest tertiles and no patient was grossly misclassified by more than one tertile. There was no difference in the cross-classification when metabolic water was taken into account. No statistically significant difference was found between WI and water loss in terms of gender, age, diagnoses, or independence vs. total dependence at meals. A difference was determined in terms of body weight and ADL function, which might be explained by the fact that patients who are not mobile, but can eat by themselves, seems to get less fluid to drink. Patients who are mobile are able to get fluid by themselves and the totally dependent patients also seems to get enough fluid. Patients who are immobile but can eat without help seem not to get enough attention from the staff, this includes patients who have had a history of stroke. This finding is supported by Blower [223], who showed that patients who where thirsty and unable to drink independently often waited to ask for help because they did not want to disturb the nursing staff.

Total energy expenditure

The mean daily TEE of the patients, according to DLW measurements in this study (paper IV), was 6.67 MJ and mean PAL was 1.20. Compared with other DLW studies involving elderly, these results show relatively low levels of TEE and PAL. A summary of 17 DLW studies give a mean TEE of 9.44 MJ and a mean PAL of 1.58 in a total of 598 participants (see Table 22). Some of the studies in Table 22 included also middle-aged people and in all studies but one, the participants were younger than the participants were in the present study. The only study with comparable figures for TEE and PAL is presented by Rothenberg et al [224] who have studied TEE in 91-96-year-old, free-living elderly and even though the mean age of the participants in paper IV was lower, other factors, such as activity and anthropometry patterns, seem comparable. Only a few DLW studies have been published on hospitalised geriatric patients. Prentice et al [219] found a mean energy expenditure of 6.10 MJ and a mean PAL of 1.51 in 14 elderly institutionalised female mental patients with a mean age of 79 years. However, low PAL values have been reported in institutionalised elderly when using indirect calorimetry. Ozeki et al [225] report a mean PAL of 1.26 (1.01-1.57) in 113 elderly (mean age 79 years), institutionalised Japanese women, 64% of whom had a PAL <1.3.

Minute-by-minute heart rate monitoring in geriatric patients to measure energy expenditure resulted in a higher estimated PAL than seen in the present study. In a study by Elmståhl [20], 30 geriatric patients in long-term care with a mean age 83 years had a mean estimated PAL of 1.48. However, 40% of the patients in Elmståhl's study had regular physiotherapy as compared with none in the present study, which could at least in part explain the higher PAL value. Rothenberg et al [84] simultaneously measured energy expenditure using both heart rate monitoring and DLW in twelve free-living elderly and report an estimated mean PAL of 1.73 from DLW measurements and 1.55 using heart rate monitoring.

Physical activity level

Only a few studies have measured the energy consumption of standard physical activities in elderly compared with younger persons. Results from these studies indicate that some standard physical activities, especially walking, call for more energy in elderly than in younger persons, while in activities that only use one arm, no significant difference in energy consumption is found [187, 189, 190]. The PAR values used in this study (paper IV) were adopted from previous published studies on energy consumption [94, 187-189]. It is important to bear in mind that the PAR values are not any exact values; rather, they are mean estimations, often based on small samples, and generalisation of the values is therefore questionable [226].

In the report "Energy and protein requirements" by the FAO/WHO/UNU [94], a PAL of 1.27 has been suggested as a minimum survival requirement, and of 1.55, as average PAL associated with a sedentary lifestyle. The PAL value of 1.27 was calculated with the assumption of 8 hours of sleep and 16 hours of activity at a PAL of 1.4. However, this is not the average activity pattern of nursing home patients, especially not in study reported in paper IV. The PAL of 1.27 as a minimum survival requirement therefore appears to fit more healthy, free-living persons, and not nursing home patients. Black et al [227], have in a meta-analysis of DLW studies, suggest a minimum PAL of 1.2 for a sedentary (i.e. chair-bound or bedridden) lifestyle. This PAL value of 1.2 is drawn as a conclusion from four studies, but only seven out of the 80 participants whom this conclusion was based on were non-ambulant elderly. Goldberg et al [228] suggest a minimum PAL of 1.35 as compatible with long-term weight maintenance in normal, healthy, free-living adults, but do not rule out that a PAL of 1.2 is possible in completely chair-bound or bedridden patients. A PAL of 1.5-1.8 has been suggested to be a sufficient level in the elderly and a PAL of 1.4 as the minimum acceptable maintenance level [229, 230]. A sedentary lifestyle among nursing home patients is probably a major factor explaining the low PAL values the present study. However, PAL values <1.2 are quite possible to obtain. In an experimental DLW study, Goran et al [231] report a mean PAL of 1.17 during repeated measurements of five younger men (mean age 23 years) living under sedentary conditions.

Even though the mean PAL of 1.2 and the range of 1.01 to 1.40 in this study (paper IV) appear to be very low, it should **not** be concluded that energy requirements of geriatric patients should be at a PAL level of 1.2. The present study (paper IV) does not indicate whether the recorded energy expenditure level was sufficient for maintaining a sufficient level of physical activity, and consequently, muscle mass, for each patient, even though the BW of the patients did not change much during the study period of almost 6 months. Therefore, the reported findings cannot be used to determine whether the patients had adapted their physical activity to a lower energy intake/expenditure or whether the energy intake/expenditure was sufficient to support an optimal PAL. It is possible that institutionalised patients can adapt and maintain their energy balance at a suboptimal level. In an experimental study by Elmståhl et al [9] of a changed meal environment and a changed mealtime serv-

Table 22. Doubly labelled water studies in elderly subjects, mean values and SD (±) (paper V).

	n	Mean age (years), number of female (F) and male (M) participants	Mean TEE (MJ)	Mean PAL	Subjects
Prentice et al 1989 [219]	14	14 F 79.0 ±0.0	6.10 ±0.00	1.51	Dementia and depression long-stay in-patients
Goran et al 1992 [281]	13	6 F 64.0 ±5.0 7 M 68.0 ±6.0	8.75 ±0.97 11.19 ±1.65	1.42† 1.56†	Healthy free-living elderly
Roberts et al [282]	15	15 M 69.2 ±1.8	10.44 ±0.38	1.75	Healthy free-living elderly
Reilly et al 1993 [283]	11	11 F 73.0 ±3.0	9.21 ±1.48	1.80	Healthy free-living elderly
Pannemans et al 1995 [284]	26	10 F 67.6 ±4.1 16 M 71.4 ±4.9	9.60 ±1.56§	1.66 1.52	Healthy free-living elderly
Sawaya et al 1995 [285]	10	10 F 74.0 ±1.4	7.59 ±0.28	1.58†	Healthy free-living elderly
Fuller et al 1996 [286]	23	23 M 82.0 ±3.0	9.20 ±1.4	1.50	Healthy free-living elderly
Morio et al 1997 [287]	12	6 F 71.3 ±2.4 6 M 68.8 ±2.5	9.60 ±0.8 12.80 ±3.1	1.76† 1.81†	Healthy free-living elderly
Poehlman et al 1997 [288]	30	17 F/13 M 73.0 ±8.0§	7.95±2.16§	1.48†§	Free-living Alzheimer's patients
Poehlman et al 1997 [288]	103	52 F/51 M 69.0 ±7.0§	9.26 ±2.15§	1.56†§	Healthy free-living elderly
Toth et al 1997 [289]	16	16 M 62.0 ±8.0	9.26 ±1.92	1.34†	Free-living Parkinson's disease patients
Toth et al 1997 [290]	12	1 F/11 M 73.0 ±6.0§	7.82 ±1.45§	1.32†	Free-living cachetic heart failure patients
Toth et al 1997 [290]	13	13 M 67.0 ±5.0	9.83 ±2.28	1.38†	Free-living non-cachetic heart failure patients
Rothenberg et al 1998 [84]	12	9 W 73.0 ±0 3 M 73.0 ±0	9.60 ±1.16 10.79 ±2.05	1.72 1.74	Healthy free-living elderly

Starling et al 1998 [85]	99	51 F 67.0 ±6.0 48 M 70.0 ±7.0	9.65 ±2.71 10.28 ±2.79	1.63 1.73	Healthy free-living elderly
Starling et al 1998 [291]	65	37 F 64.0 ±8.0 28 M 64.0 ±7.0	8.74 ±1.72 11.60 ±2.33	1.51 1.71	Healthy free-living elderly
Kaczkowski et al 2000 [292]	76	76 F 67.3 ±11.5	10.02 ±3.12	missing	Healthy free-living elderly
Rothenberg et al 2000 [224]	21	13 F 91-96 y 8 M 91-96 y	6.30 ±0.81 8.10 ±0.73	1.19 1.36	Healthy free-living elderly
Seale et al 2002 [86]	27	13 F 73.5 ±4.2 14 M 74.1 ±4.1	9.44 ±0.90 12.43 ±1.63	1.82† 1.83†	Healthy free-living elderly
Present study	11	5 F 86.4 ±3.6 6 M 84.2 ±4.6	6.69 ±0.89 8.26 ±1.04	1.30 1.25	Dementia nursing-home patients
Present study	7	4 F 83.3 ±9.4 3 M 81.0 ±14.2	5.13 ±0.66 5.90 ±0.61	1.16 1.06	Stroke nursing-home patients
Present study	13	9 F 90.0 ±4.4 4 M 82.5 ±6.2	6.16 ±1.23 7.55 ±1.12	1.20 1.16	Geriatric nursing-home patients
Total	629	≈74	8.91	1.51	
		F 188 76.3	7.92	1.51	Only with complete sex specific data included
		M 194 74.2	9.83	1.51	Only with complete sex specific data included
Exclusive present study	598	≈72	9.44	1.58	
		F 170 73.2	8.50	1.59	Only with complete sex specific data included
		M 181 72.0	10.54	1.61	Only with complete sex specific data included

† Value not given, calculated from mean
§ Sex specific values not given

ing system in a geriatric ward, the EI in 16 geriatric patients increased by 25% during a 4-month period. Even though the EI increased there were no changes in the participants' BW during the experiment period, indicating that the patients' physical activity also increased during the experiment. The studies on human semi-starvation by Keys et al [232, 233] has also shown that it is possible to attain energy balance at a new low level after a period of restricted EI. Patients' adaptation to a low level of TEE does not promote health in the longer term and gives no flexibility or space for any exercises or increased physical activity. On the contrary, this situation will discourage healthy muscle activity and may lead to a higher risk of amyotrophia and sarcopenia and in turn, a lower degree of physical activity that could have a negative influence on the patients' health [234]. This could create a vicious circle and once started, it will be difficult for the elderly to get out of it.

Total energy expenditure in geriatric patients is generally lower than in healthy younger people and this is especially true of patients with diseases that restrict the physical activity. The patients in the present study were tested for metabolic thyroid and liver diseases, som that can be ruled out as sources of error. Only one patient had a diagnosed cancer. Even though the four patients with reported fever during the DLW measurement period had a significantly lower PAL than did the patients without fever, the TEE did not differ significantly between patients with and patients without a fever. The subjects in this study (paper IV) were nursing home patients, many of whom had multiple diseases that could negatively affect physical activity. The low PAL in this study was seen especially in stroke patients and in patients with other diagnoses, whereas patients with dementia showed higher levels of physical activity (see Table 22). Only twelve of the 31 patients could move about independently and none of the patients took part in any regular physical training or rehabilitation. The nursing home environment itself may also have had a restricting influence on the patients' physical activity. Only one of the patients participated in the daily activities in the nursing home, besides the personal activities. Consequently, there seem to have been few opportunities for physical activity for the patients in the study reported in paper IV.

The doubly labelled water method

The DLW method is at present the best method for measuring human TEE in field conditions. The error of the analytical precision of the method has been reported to be in the range of ±3-6% [125, 129-131]. In the present study (paper III and IV), the measured TEE is a mean value of measurements during 3 weeks. Variation of physical activity and the variation in the DLW technique together with the uncertainty of PAL estimations could possibly explain some of the variation of the used equations.

Prediction of energy requirements

Thirteen equations to predict BMR/TEE in geriatric patients were identified and tested against TEE measured by DLW in combination with an estimation of PAL

in 31 geriatric patients. The best predictive equation (E10) in this study was the one by Westerterp et al [198]. However, the equation by Westerterp et al may be too complex to use in a clinical setting. A somewhat easier equation to use is the one by FAO/WHO/UNU [94] based on BW and height (E2). If only BW is to be used, the equation (E7) by Owen et al [194, 195] is the equation to be recommended.

Equations using BW [235], or body-weight and height [230] have been suggested to provide reasonable estimates of BMR in the elderly. Out of the 13 tested equations in this study (paper IV), the BMR predictive equations of Harris and Benedict [191] are perhaps one of the most commonly used. Even though the original study by Harris and Benedict (series I) [191] did not include many elderly subjects, Benedict later published other studies (series II) [236], (Bangor series) [237] that include elderly, but without changing the original equations published in 1919. During the past few decades, the Harris-Benedict equations have been criticised for providing unreliable results [238-241]. The predictive equation of Harris and Benedict [191] accepts a difference of ±10% between the predictive and the measured value in normal subjects [236]. In the study presented in paper IV, the Harris-Benedict equations, together with an estimated PAL value, underestimated DLW-measured TEE by a mean 12.7% and also underestimated TEE in all three subgroup analyses of sex, physical activity, and age. Similar underestimations were noted for equations E8 [196], E9 [197] and E13 [201]. The pattern was similar in equation E3 [94], since even though the mean underestimation of TEE was 6.9% for all subjects, the equation especially underestimated TEE for men (-14.4%) and young subjects (-10.5%). In the equations E11 [199] and E12 [200], the opposite was found. These two equations overestimated mean TEE in all patients by 12.5% and 19.6%, respectively, and in some subgroup analyses including men, low PAL, and elderly patients, there was an overestimation of >20%. The equations E11 and E12 predict TEE but unlike the rest of the equations used in this study, they do not predict BMR and it seems that these two equations are based on subjects with a higher PAL than seen in the patients participating in our study.

Schofield et al [242] reviewed the literature on BMR/RMR and provided a series of predictive equations [192]. These formed the basis for the equations presented in the FAO/WHO/UNU report [94]. Altogether, five equations (E2-E6) in the present study are presented by, or based on data from, Schofield's, and all but one (E3) of these predict TEE within the ±10% range. A meta-analysis by Elia et al [243] of DLW studies in healthy, free-living elderly compared measured BMR with estimated BMR using Schofield's BMR equation with BW (E4) [192] as a predictor. In 88 women (mean age 68 years), mean measured BMR was 5.53 MJ and mean predicted BMR 5.47 MJ; corresponding figures in 98 men (mean age 71 years) were 6.40 MJ and 6.23 MJ, respectively. In the present study, equation (E4) was among the equations that could predict TEE within a range of ±10%.

Of the 13 tested equations in this study (paper IV), seven (E2, E4, E5, E6, E7, E10, E13) were able to predict TEE within a range of ±10% and four of these (E2, E5,

E7, E10) to predict TEE within a range of ±5%. Equation E5 [192], however, had a slightly higher RMSE and a slightly poorer result in the subgroup analysis, especially for men, younger subjects, and patients with a high PAL. The best predictive equation in the present study was E10 [198], with a 1.4% mean overestimation of TEE and the lowest RMSE, of 0.71 MJ. The two second best equations were E2 [94] using both BW and height, and E7 [194, 195] using only BW.

Objections against using height in BMR/TEE predictive equations could include a reduced compliance among geriatric patients, technical difficulties, and bias with respect to vertebral compression fractures and underestimating of stature [56]. Surprisingly, however, three out of the seven best predictive equations, and two out of the three best equations, in this study use both BW and height in the BMR equation.

Even if a predictive value on energy requirement is possible to obtain through a combined estimation of BMR and PAL, individual adjustments will still have to be made in clinical use based upon individuals variation and BW changes.

A more simple way to calculate and estimate TEE in geriatric patients could be to use a formula of kcal/kg BW. Assuming a mean BMR of 21 kcal/kg BW, supported by previous measurements [219, 224, 225] and the results of this study, TEE for bedridden geriatric patients could be estimated to 24 kcal/kg BW, corresponding to a PAL of 1.14. Geriatric patients who are mostly sitting, for example in need of a wheel-chair to move about the TEE could be estimated to 26 kcal/kg BW, corresponding to a PAL of 1.24. Ambulatory geriatric patients TEE could bee estimated to 29 kcal/kg, corresponding to a PAL of 1.38 and if the patients are in rehabilitation or in some kind of physical training etc the TEE could be estimated to 34 kcal/kg BW, corresponding to a PAL of 1.62. An EI corresponding to 24 kcal/kg BW will not allow for desirable physical activity and will certainly not allow for increasing physical activity. Furthermore, conditions that increase energy needs, such as inflammation, fever and infections are common among institutionalised frail elderly. It is important to use "ideal body weight" and **not** present BW when estimating TEE since malnourished patients could have an underweight. There is a need for further studies on simple ways to predict energy requirements in geriatric patients.

The FAO/WHO/UNU recommendations published in 1985 [94] were based on a conference held in 1981. During the 21 years since 1981, many studies have been published on energy expenditure in humans using the DLW technique. The results of the studies presented in this thesis and other studies and the results from last few decades of DLW work suggest a need to re-evaluate energy requirement recommendations and the prediction of energy needs for the elderly in general, and for geriatric patients in particular.

Diet recording

There is not yet any method to get accurate determination of dietary intake, all methods used have its limitations and some degree of uncertainty [102, 103, Cameron, 1988 #133, 222, 244]. Many studies have found that self-reported EI mostly is underreported in dietary surveys [222, 245] also in the elderly [86, 246].

Using standardised portion sizes in quartiles the dietary record routine estimates total intake during lunch and supper, but not intake of specific food items. This may lead to some uncertainty with regard to estimating vitamin and mineral intake at an individual level. Since there is little literature in recent years on the dietary intake of frail, elderly people at a micronutrient level, it is important to report the results, even if some uncertainty might be anticipated regarding some of the reported vitamin and mineral intake.

Number of recording days

It has previously been suggested that a 7-day dietary recording period is long enough to correctly rank and categorise by tertiles 80% of individuals' intake of energy, carbohydrates and protein with 95% confidence [102, 103]. The limitations are the result of intra- and intersubject variation in dietary intake. The 7-day dietary recording was chosen for the reproducibility (paper II) and validity (paper III) studies also because it would cover all days of the week. In the reproducibility study (paper II) 75% of the patients were classified correctly in terms of EI and only a few patients were grossly misclassified by more than one tertile. In the validity study (paper III), 80% of the patients were correctly classified in the lowest tertiles, and no subject was grossly misclassified by more than one tertile. Since the dietary record routine is intended to be used as a screening instrument to detect patient with malnutrition or at risk of becoming malnourished, it is vital to detect the patients with the lowest intake of energy is vital to detect. It is possible that a less number of days are required when using the dietary record routine in a clinical setting to monitor the patients intakes of energy and fluid. It has been suggested that 3-4 days might be sufficient [247, 248], but that has to be evaluated in further studies of the dietary record routine.

Nutrient databases

Food items vary in nutrient contents owing to: a variation from day to day, different regions, different seasons, geographical areas, different breeding, different storage, different processing and so on, while the nutrient data in food composition tables are a mean value [249]. The nutrient contents in food composition tables is mostly based on raw food items, while the foods consumed to a large extent are prepared in some way. The calculation of the nutrient in-take in the studies (paper I, II, III and V) was based on the recipes. Nutrient losses during the food preparation and transportation have not been taken into account. Such losses would affect vitamin C and to some

extent thiamine, riboflavin and vitamin B6 [172]. The true intake of these nutrients is probably lower than reported in this study.

In paper V the same nutrient database was used for all samples to calculate nutrient content, so that a comparison between the intake during the different study years could bee done without changes in the database over the time-period making the difference.

The dietary intake of the patients in paper I were re-coded when the data was used in paper V. In almost all reported nutrients the intake analysed in paper V was higher, for example the EI was 6% higher in women and 5% higher in men. However, the intake of iron was lower, due to fortification in flour ended in 1994 [250], making the reported intake of iron in paper I probably to high since the older nutrient database used did not take this into account. The difference between the reported nutrient intake in paper I and V are the combined effect of the re-coding and a different nutrient database used.

Energy intake

The noted dietary intake in geriatric patients was low. In paper I, 84% of the patients had an EI below estimated energy expenditure, and 30% of the patients had an EI below estimated BMR. Eighteen percent of the patient died within 6 months and the deceased had lower EI at baseline than the others, 1185 kcal vs. 1401 kcal.

In paper V, 57% of the women and 77% of the men did not have a sufficient EI. With regard to vitamins and minerals, there was a large proportion that did not reach RDI levels, according to the NNR96, or even the minimum safety level of intake. The use of dietary supplements in the study population was low, only 7% of the patients were given dietary supplementation on a daily basis and only 15% receive dietary supplements at some point during the dietary registration. Moreover, the use of dietary supplements decreased during the 4-year study period. Only 23% of the patients were given medical vitamin/mineral supplementation, nearly half of whom were on vitamin B12 and/or folate and/or iron supplementation and only 3% on multivitamin and/or mineral supplements. The use of dietary supplements in this study was in fact lower than that in a middle-aged Swedish population, in which 37% reported use of dietary supplements [251] and in a study of free-living healthy elderly 44% of the females and 41% of the males took supplements regularly [252]. The intake of vitamin B in the present study was, however, good. This was due mainly to a high intake of bread and other cereal products which in Sweden are fortified with vitamin B. However, since the flour mills in Sweden have in the past year stopped fortifying their flour with vitamin B there will be a lower intake of riboflavin, niacin, thiamine and vitamin B6 in the future. In general, the elderly consume smaller amounts of food [7, 253], but they have the same or even higher micronutrient needs as younger people, which puts a greater demand on food planning and preparation in this group.

Intake of calcium and vitamin D

Adequate intakes of calcium and are important to avoid osteoporosis [91]. This is especially important for elderly with a low sunlight exposure [254]. Reduced supplies of calcium in the human body are associated with a reduced bone mass and osteoporosis [91] and a vitamin D deficiency leads to osteomalacia [91] . Increased rates of fractures have been reported in prospective studies of elderly with depletion of calcium and vitamin D [255, 256].

The mean daily calcium intake (paper V) was above the RDI in both women and men. The high calcium intake is probably owing to that milk is often used as table drink to all major meals and cheese is frequent used on the bread. Patient with low intake of calcium were often people who did not drink milk. There are an on-going debate whatever the RDI recommendation of 800 mg of calcium/day [92] is sufficient or a higher intake is needed as one part of preventing osteoporosis [178, 257]. However, the intake of vitamin D was poor, not one single patient could reach the RDI of 10 µg/day. The mean daily intake was 2.9 µg in women and 3.2 µg in men. In women 41% had an intake below the minimum safety-level of 2.5 µg, putting them in a risk of deficiency. An insufficient vitamin D intake can have a direct influence on the risk of develop or deteriorate osteoporosis. In elderly the ability to produce vitamin D through exposure of sunlight deteriorate [89] and many of the elderly in sheltered housing are seldom exposed to sunlight. A routine vitamin D supplementation and even also of calcium has been suggested as a supplementation for all elderly, especially women, at risk of osteoporosis to prevent osteoporotic fractures [91]. The use of dietary supplementation with medication was low in the present study. Information on medication was collected in 144 patients and 15 patients (10%) were supplemented with vitamin D, but only 5 patients (3%) with calcium.

Dietary supplementation

A paradox is that in clinic 3% fat milk (“standardmjölk”) is often recommended as table drink for patient in sheltered housing as a way to increase the EI. However, in Sweden 3% milk is not fortified with vitamin A and D as the milk products with lesser fa tcontent [179]. A milk consumption of 500 mL/day is not unusual and if this was consumed as 1.5% fat milk (”mellanmjöl”) which in Sweden is fortified with vitamin A and D, the EI would decrease by 65 kcal/day, while the vitamin A intake would increase by 95 µg/day and vitamin D by 1.8 µg/day. Recently it has been suggested that there is a need of a different kind of milk in young children with a lower protein and a higher iron contents [258]. Really, there is also a need of special kind of milk for the elderly, high on energy and calcium, fortified with vitamin D and perhaps also other nutrients. Even if a daily calcium and/or vitamin D supplementation in the elderly is needed, it should not be forgotten that a daily dose of 30 minutes sunlight may prevent vitamin D insufficiency in the elderly [90]. Vitamin D deficiency may also be associated with a muscle weakness in the elderly and thereby also with increased risk of falls [259, 260].

There is therefore a need for improvements in the mealtime situation of geriatric patients to promote an increased energy and nutrient intake. The nutritional needs of individual patients must be recognised by the nursing staff and others involved in the patients' care. The number of meals must be increased, so that there are three major meals plus three or four in-between meals per day. The overnight period without food and fluid intake should be shortened. More "complete meals", according to the FBCE classification [117], must be served. There ought to be an increased energy and protein content in the major meals without increasing the size of portion. A reduction of portion sizes does not seem to promote an increased food and EI in geriatric patients [261]. Ödlund Olin et al [213] showed that energy-enriched meals can improve geriatric patients' EI and by using only "natural" products such as more butter, cream, crème fraîche, milk and oil, the mean EI was increased by over 800 kcal/day without any changes in the consumed amount of food [213]. However, I believe that it is not enough to just increase energy and/or protein intake because a large proportion of the patients has a low micronutrient and mineral intake. A change is needed in the strategy for reducing malnourishment and malnutrition in the elderly. There is a need for a general dietary supplementation given to elderly people in sheltered housing. Instead of identifying patients at risk of malnutrition, all patients in sheltered housing should therefore be given full daily dietary supplementation, with the exclusion of people with obesity. This is supported by the findings in this study, where the intake of vitamin D, selenium, folate, vitamin E and iron was below RDI in almost all patients. Larsson et al [21] have shown that a dietary supplements can both increase EI and reduce mortality. The nutrient quality of the between-meal snacks could also be increased as a way to increase the dietary intake, as many of the between-meal beverages served was sugar based and low nutrient soft drinks.

The high proportion of patients with an insufficient dietary intake during the 4-year study period as well as the lack of improvement in patients' dietary intake, especially for men, indicate that there seems to be a failure in the organisation of nutritional care of geriatric patients. The findings are especially interesting in the light of an intense public debate that was ongoing during the study period, about malnutrition and care of the elderly in sheltered housing in Sweden. Information and courses on nutrition have been offered to the nursing staff in the municipality where the study was performed. Reports indicates a higher care dependency in the patients during the last years and an increased nursing workload in sheltered housing [158-160] also in the local municipality were the studies in this thesis was performed [262, 263]. The organisation of the care of the elderly and the routines at the wards, as well as the numbers of persons in the nursing staff might also have a great influence on the patients' dietary intake and nutritional status. However, this perspective has to bee further investigated. The difference in EI of patients was greater between wards than were the differences between the three periods of the study (paper V), which suggest that the staff's interest of and knowledge in nutritional care are of great importance. However, even in the "best" of the ten different wards in this study the mean overnight period without any food intake was almost 15 hours, with over 95% of the EI occurring during 9 hours and the EI from between-meal snacks being below 20%.

In other words, it appears that the nursing staff does not ensure that the patients' individual nutritional needs are met. An important difference between patients with an EI above and patients with an EI below calculated energy requirements appears to be BW. The mean BW of patients with an EI above calculated energy requirements was 13 kg lower than the patients with an EI below calculated energy requirements. It is likely that the same amount of food and fluid was served to all patients, no matter what their individual needs might be, and that the recorded differences in dietary intake are a reflection of the patients' ability to eat and drink the served amount rather than reflecting an individual difference in the amount served. This phenomenon was also observed for elderly in surgical care by Ulander et al [264].

Mealtime habits

The FBCE tool showed that patients with an EI below calculated energy requirements had ingested fewer "complete meals", more "incomplete meals", fewer "prepared meals", more "quick prepared meals", and more between-meal snacks occasions with no intake. The characteristics of the meal pattern of patients with an inappropriate dietary intake can be used as guidelines for future health strategies. The high proportions of "low-quality snacks" suggest that these should be replaced, or supplemented, with dietary supplements. Previous studies have shown that giving dietary supplements to patients with a low intake could increase their nutrient intake [265] and administration of dietary supplements between meals instead of with meals may be more effective in increasing the EI in the elderly [266]. "Quick prepared meals", which often was also classified as "incomplete meals", should perhaps be reduced in favour of "complete meals". "Complete meals" were less often consumed among patients with a low EI. The FBCE tool has not been previously used in geriatric patients in sheltered housing for categorising their present dietary intake and it is likely that it has to be modified to more accurately describe the dietary intake of patients living in sheltered housing. For example, the intake of dietary supplements has been categorised as "category F - low nutrient density" (see Appendix 1) even though liquid dietary supplements are balanced and complete. Also, there is no simple way of reporting an increased EI with the FBCE tool. Some adjustments were already made in using the FBCE tool in this study for categorising porridge (see Appendix 1). Possibly could more finformation be retrivied if using the tool also to describe the diurnal variations in intake of different nutrients.

Almost all (97%) of the EI in this study occurred during 9 daytime hours (usually from about 08:00 to 17:00). The mean overnight period without any food intake was about 15 hours, which is in agreement with that reported by Bachrach-Lindström in a study performed in nursing homes [267]. The recommended maximum of overnight period without any food is 11 hours [176]. Patients who had a shorter overnight period with out any food intake (lowest quartile) had a mean daily EI of almost 300 kcal more than did patients with longer overnight period without any food intake (highest quartile). By the same token, patients with more meals/day (highest quartile) had a mean daily EI of almost 300 kcal more than did patients with fewer

meals/day (lowest quartile). Only a few of the major meals were served without any intake in individual patients, but only about 13% of the EI came from between-meal snacks. Since only a few of the patients did not have an intake during major meals and since almost half of the four daily between-meal snack periods in this study was without any intake, a way to increase the EI could be to offer the patients more between-meal snacks.

Even if the PAL was only estimated in 31 of the patients, there is no reason to believe that the activity-pattern in the rest of the patients was any different. Most of the patients had chronic diseases and multiply diagnoses, and were highly dependent on nursing staff in their ADL functions; also, most had spent a long time in the nursing home. This may have had a negative influence on their physical activity and the number of waking hours and possibly this may have contributed to the long overnight period without any food intake. However, it has been documented that a state of semi-starvation decreases activity and increases the need of sleep [268]. A previous study in a psycho-geriatric unit reported that patients spent 51% of a 14-hour observation period alone [269].

Fluid intake

The recommended daily FI in elderly people is 30 mL/kg BW [109]. However, it is not clear whether this amount refers to FI or to WI, calculated from both food and FI. The mean daily FI of about 22 mL/kg BW in this study (paper V) is far below the recommended amount, but if the water intake is taken into account, the mean daily intake in the present study (paper V) was about 30 mL/kg BW.

The mean daily fluid intake in men was only about 100 mL more than that in women despite a difference in mean BW of 14 kg (paper V). Taking mean BW into consideration the men had a lower daily fluid intake than women did. The result suggests that the individual needs for fluid were not being met. Other studies have shown that geriatric patients do not have a sufficient fluid intake [270] and that dehydration in the institutionalised elderly can be an indicator of inadequate care [271]. Blower [223] reports that patients, who are thirsty but unable to drink independently, often wait to ask for help because they do not want to disturb the nursing staff. Adams [272] showed that 75% of the fluid intake by geriatric patients takes place during 12 hours (usually from 06:00 to 18:00) during daytime and that the patients often drink the entire amount offered. In the study presented in paper V, about 93% of the fluid intake happened during 10 hours (usually from 08:00 to 18:00) and about 74% of the fluid intake took place during the major meals of breakfast, lunch and supper. Since it was not record the actual time at which the beverages were consumed, but instead recorded the times at which beverages were served, the present data on the overnight period without fluid intake may be more imprecise than those on non-intake of food since not all fluid intake always take place immediately when served. Voluntary avoidance of fluids during the evening and at night in patients who need toilet assistance should also be taken into account [273].

Protein-energy malnutrition

Out of 81 patients (paper II) 23 (28%) were classified as having PEM. However, a weak association was found between patients with PEM and patients with an EI below calculated energy requirements. Out of the 23 patients classified as having PEM, only five also had an EI below calculated energy requirements. There was only a small difference in crude values in EI between patients with and patients without PEM. With regard to EI/kg BW, patients with PEM had a mean daily intake of 35.9 kcal compared to 28.4 kcal in patients without PEM. However, there was a large difference in BW between patients with and without PEM and all but two of the 23 patients classified as having PEM had a BMI below the median. A possible explanation for this observed result is that nursing staff may have identified patients with PEM and given them dietary supplements at some point. However, this does not explain the negative energy balance in the patients without PEM. Could it be that the nursing staff were able to identify patients with PEM but were unable to identify patients at risk of becoming malnourished? That explanation seem to be less likely, since several studies [13-15] have shown that health care professionals fail to recognise and identify patients with malnutrition or at risk of be-coming malnourished, and the use of dietary supplements in this study was very low, only 3% of the patients received dietary supplements on a daily basis.

The fact that patients with PEM had a higher EI/kg BW than patients without PEM indicates that fulfilling energy requirements expressed as EI/kg BW is not sufficient for appropriate estimation of dietary intake or as a tool for fulfilling energy needs. The risk when using the present BW when calculating intake levels instead of "ideal body weight" for gender, age and stature, is an underestimation of needs. The reason is that patients with PEM most likely have lost BW.

Since PEM often develops through a longer period of semi-starvation, the EI of the patients with PEM does not necessarily reflect the EI during the period when they developed PEM due to illness. Protein-energy malnutrition could also have developed from a higher energy need over a longer time period that had not been met by an equally increased EI. However, the most conceivable explanation is that the nursing staff does not see to the patients' individual nutritional needs. It is likely that the same amount of food and fluid is served to all patients, no matter what their individual needs might be, and as previously mentioned, that the registered differences in dietary intake are a reflection of the patients' ability to eat and drink the served amount rather than reflecting an individual difference in the amount served.

Nutritional care

Insufficient awareness of patients' individual nutritional needs by nursing staff has previously been described in surgical care [264]. Sidenvall et al [274, 275] found that mealtime procedures at institutions for elderly people are often governed by the nursing staff's routines and not by individual patients' needs, with mealtimes being more

task-oriented than patient-oriented and therefore failing to meet the patients' nutritional needs. Other studies have also shown a lack of knowledge in assessing patients' nutritional needs, as well as inadequate action to meet these needs [276, 277].

Despite the observed situation of no or only little improvement during the 4 study years, there are ways to improve patients' nutritional care. Olsson et al [278] showed that education and training programme for nurses can improve nutritional assessments and interventions. Elmståhl et al reported the finding that a changed meal environment [9] or supplementation [265] may increase the patients' EI by as much as 25%. Christensson et al [279] showed that nursing care based on individual nutritional requirements, resources and desires can improve dietary intake, nutritional status and functional capacity in malnourished geriatric patients. Ödlund Olin et al [213] showed that energy-enriched meals can improve patients' EI. Likewise, Larsson et al [21] found that dietary supplements can both increase EI and reduce mortality, and Wilson et al [266] found that administration of dietary supplements between meals instead of with meals may be more effective in increasing the EI in the elderly. In summary, it is crucial that nursing staff is appropriately trained in assessing patients' dietary intake. Pokrywka et al [280] suggest that a feasible solution would be to develop a standardised training programme to be offered to nursing staff at regularly scheduled intervals to compensate for the large turnover in nursing staff.

Conclusions

The 7-day dietary record routine based on standardised portion sizes and household measuring seems to have a good reproducibility and validity in assessing the intake of energy and fluids in geriatric patients'.

Thirteen different equations were used for prediction of BMR/TEE and then compared with DLW-measured TEE. Only three of the equations proved to give accurate estimations in geriatric patients taking age, sex and physical activity into consideration.

A high number of geriatric patients have an energy and nutrient intake far below present recommendations. The mean intake of vitamin B and C, calcium and zinc for the whole group was above the RDI in NNR96, but for the other nutrients the mean intake at a group levels was below the RDI and even below the minimum safety level. Especially the intake of vitamin A, vitamin D, vitamin E, folate, iron and selenium were low.

A higher mortality was found among those with an EI below median (1378 kcal), independently of diagnoses.

Almost the entire energy intake of the patients occurred within 9 hours during daytime. There was a mean 15 hours overnight period without any food intake and minor fluid intake. Only about 13% of the total EI came from between-meal snacks.

There is a lack of ability in nursing staff to identify and correctly estimate geriatric patients' nutritional needs. A change in the strategy for preventing malnutrition in the elderly is therefore clearly needed. There is a need of general daily dietary supplementation to be given to all elderly people living in sheltered housing. This means that instead of identifying patients at risk of malnutrition all patients in nursing homes and patients in community residence homes should be given full daily dietary supplementation unless no contradicting health conditions exists.

Suggested further research

The research has been focused on the dietary intake of the patients. Large differences in dietary intake were noted between the wards, suggesting that the nursing staff knowledge, attitudes and actions are of great importance. In future, when studies on dietary intake in elderly in sheltered housing is done, it is important also at the same time investigate the nursing staff knowledge, attitudes, documentation and actions regarding diet and patients requirements.

In this thesis the focus has been on methodological aspects. In the future it would be interesting to find out if an implementation of the dietary record routine in hospitals and sheltered housing for the elderly also have an effect on the nutritional care of the patients and of the nursing staffs knowledge about nutrition care. It might also be of interest to find out the minimum number of days necessary to estimate patients' energy and fluid intakes when using the dietary record routine in hospitals and sheltered housing for the elderly.

The recommended intake of fluid and/or water in the elderly seem to be uncertain. This is a field that needs further investigations. Further studies on the level of physical activity of institutionalised elderly are also needed.

The intake of some nutrients, like vitamin D was very low in the studies. Could an alternative choice of food increase the intake of vitamin D or is there a need for specially designated functional foods for frail elderly, rich in energy, iron, vitamin D and perhaps other nutrients as well?

Populärvetenskaplig sammanfattning

Undernäring hos äldre

Många av de äldre patienterna som är inlagda på sjukhus eller som bor i särskilda boenden inom äldreomsorgen är idag undernärda. En sammanställning av Socialstyrelsen över svenska studier under de senaste 20 åren visade på en genomsnittlig frekvens av undernäring på 28%.

Ett otillräckligt kostintag leder till undernäring. Kroniska sjukdomar är ofta en bakomliggande orsak till undernäring, men även de rutiner eller brist på rutiner som finns på sjukhus och vårdavdelningar kan bidra till att patienter blir undernärda. Vid undernäring råder det en obalans mellan energi- och näringsintag respektive energi- och näringsförbrukning. Ett för litet energi- och näringsintag under en längre tid kan liknas vid en slags smygande svält. Undernäring ökar risken för komplikationer, såsom infektioner, trycksår och en försämrad sårläkning. Konsekvenser av undernäring blir också en förlängd vårdtid och ökade sjukvårdskostnader samt, som en yttersta konsekvens, försämrad överlevnadsförmåga.

Syftet med avhandlingen var att utveckla och pröva användbarheten av en nutritionsjournal hos äldre patienter på sjukhus och inom äldreomsorgen.

Nutritionsjournal

Jag har utvecklat en Nutritionsjournal, som består dels av en mat- och vätskeregistreringslista där patientens intag registreras under ett dygn, dels av en journalhandling där uppgifterna från mat- och vätskeregistreringen kan dokumenteras. Kostre-gistreringen görs under sju dagar av vårdpersonalen, som uppskattar den serverade och konsumerade maten och dryckerna enligt en standard. Utifrån en schablonbeskrivning av energiintag för olika komponenter och livsmedel, summeras det uppskattade intaget och registreras i Nutritionsjournalen, där ett medelvärde för veckoregistrering beräknas och jämförs med rekommendationer. Till Nutritionsjournalen kopplas också uppgifter om längd, vikt, viktutveckling mm. En manual för Nutritionsjournalen med instruktioner till vårdpersonalen om hur den skall användas har också arbetats fram.

I den första delstudien studerades 61 patienters mat- och vätskeintag på två sjukhemsavdelningar. Resultatet visade att 85% av patienterna hade ett energiintag som understeg beräknat energibehov och att knappt en tredjedel hade ett intag som understeg basal ämnesomsättning. För dem som hade ett energiintag som understeg medianvärdet var dödligheten ökad vid sex månaders uppföljning, medan ett högre energiintag än medianvärdet var förenat med en lägre risk för död.

Reproducerbarhet

I delstudie två studerades reproducerbarheten, dvs om man fick samma resultat om man upprepade mätningen. Två kostregistreringar på sju dagar vardera och med en kortare tidsperiod mellan registreringarna gjordes av vårdpersonalen på 81 patienter från fem sjukhemsavdelningar. Av de 81 deltagarna var 28% undernärda. Medelintaget av energi för period 1 var: 1688 kcal och period 2: 1636 kcal. Medelintaget av vätska för period 1 var: 1251 ml och period 2: 1194 ml. Resultatet visar således på en god reproducerbarhet när det gäller energiintaget.

Validitet

I delstudie tre studerades validiteten, dvs hur noggrant metoden mäter. Deltagarna i valideringsstudien rekryterades från delstudie två. För att få delta i delstudie tre krävdes en stabil kroppsvikt under fyra månader samt att patienten inte var undernärd. Kostintaget registrerades under sju dagar av vårdpersonalen för 31 patienter och samtidigt utfördes en mätning av patienternas energiomsättning med hjälp av metoden dubbelmärkt vatten. Detta är den första studie som publicerats där energiomsättningen hos geriatriska sjukhemspatienter studerats med hjälp av dubbelmärkt vatten. Hypotesen var att om en person har stabil kroppsvikt, inga akuta eller kroniska sjukdomar som kan påverka ämnesomsättningen i kroppen, så är energiintaget lika stort som kroppens energiomsättning. Genom att mäta kroppens energiomsättning kan vi få ett mått på hur pass tillförlitligt kostintagsregistreringen är när det gäller energiintaget. Kostregistreringen visade på ett medelintag av 1727 kcal medan energiomsättning låg på 1595 kcal. Kostregistreringsmetoden överskattade med i genomsnitt 8 % och resultatet visar således på en god validitet i instrumentet.

Energibehov

I delstudie fyra användes resultatet från delstudie tre för att se hur man enkelt och korrekt kan beräkna energibehovet hos äldre patienter. Tretton olika ekvationer som beräknar det basala energibehovet hos äldre granskades. Ekvationerna användes tillsammans med en uppskattning av patienternas fysiska aktivitet och jämfördes detta med energiomsättningen hos 31 sjukhemspatienter. På så vis identifierades tre ekvationer som bättre än de övriga kan beräkna energibehovet hos äldre patienter.

Måltidsmönster

I delstudie fem har kostintag och måltidsmönster för 220 patienter från sju sjukhemsavdelningar och tre särskilda äldreboenden studerats. Materialet är insamlat mellan åren 1995 och 1999, och något förbättrat intag med tiden har inte kunnat upptäckas. Däremot är det stor skillnad mellan de olika avdelningarna trots att patienternas behov i stort inte varierade. Sextiotvå procent av patienterna hade inte ett energiintag som uppfyllde det beräknade energibehovet och 97% av energiintaget gjordes under en tidsperiod av nio timmar med en genomsnittlig nattfasta på 15

timmar. Patienter som hade en kortare nattfasta hade också ett större energiintag. Enbart 13% av energiintaget kom från mellanmål. Patienter som åt många mellanmål per dag hade ett högre energiintag. Det verkar som om personalen inte bedömer och ger patienterna en individuellt anpassad mängd mat och dryck. Intaget av vitaminer och mineraler understiger i vissa fall inte bara det rekommenderade intaget utan också den rekommenderade säkerhetsmarginalen för att undvika bristsjukdomar. Med tanke på det låga intaget av såväl energi som vitaminer och mineraler så menar jag att det finns ett behov av att ge alla icke överviktiga äldre på sjukhem och i särskilda boenden fullvärdiga och dagliga kosttillskott, istället för att endast identifiera och kompensera de patienter som är i riskzonen för undernäring.

Hittills har det saknats tillförlitliga kostregistreringsinstrument som kan användas på sjukhus och inom äldreomsorg. Avhandlingen visar att den framarbetade metoden, Nutritionsjournalen, är ett användbart och tillförlitligt instrument som kan hjälpa vårdpersonalen att upptäcka undernärda patienter och patienter i riskzonen för att utveckla undernäring. I förlängningen är det därmed också möjligt att metoden kan bidra till att minska förekomsten av undernäring hos äldre patienter på sjukhus och inom särskilda boenden inom äldreomsorgen.

Acknowledgements

I wish to express my sincere gratitude to all those who in various ways have contributed to this thesis and especially to:

My head supervisor, Professor, MD, Sölve Elmståhl and my co-supervisor RN, Dr Med Sc, Kerstin Ulander. Without your help, I might still be planning instead of doing.

Dietian Vlasta Blabolil for all help and patience with all of my questions.

Professor Klaas Westerterp for help with the DLW calculations.

Dietian Margaretha Andrén, Catering Manager Birgitta Heuck-Lawesson and RN Eva Robertsson, who all took part in differnt ways in the research.

Colleagues at the former Clinic of Geriatrics and Rehabilitation at Värnhems Hospital, Malmö, and especially RNT Carina Mohlin, who in some way got me in to this area of research, and RN MSc Kerstin Sjöström for help and support in many ways.

All staff at Medical Library, Malmö University Hospital, who manage to provide my with a never ending request for articles and books.

Professor Lennart Råstam, Head of the Department of Community Medicine and Professor Sven-Olof Isacsson former Head of the Department of Community Medicine, for providing good working conditions at the department.

The staff at Department of Community Medicine and especially University Sectretary Cecilia Hylkén, System Engineer Sivert Carlsson and Computer Technician Roger Linder. The staff at Malmö Diet Cancer Study for interesting methodological discussions. RN Maj-Britt Bengtsson for many interesting discussions.

All the patients, their relatives and nursing staff that took part in the studies.

Financial sponsor of the research:
Medical Faculty, Lund University, Lund, Sweden; The Municipality of Malmö, Malmö Sweden; The Swedish Foundation for Health Care Sciences and Allergy Research (grant No. V97-234 and V99-090), Stockholm, Sweden; Påhlsson's Foundation, Malmö, Sweden.

The Department of Clinical Nutrition, Lund University Hospital, Lund, Sweden; The Family Janne Elqvist Foundation, Nybro, Sweden; Fresenius Kabi AB, Uppsala, Sweden; Findus Diet, Svenska Nestlé AB, Bjuv, Sweden; Geriatric Development Centre, Malmö University Hospital, Malmö, Sweden; Geriatric and Internal Medicine Care Unit, Malmö University Hospital, Malmö, Sweden; The Gun and Bertil Stohnes Foundation, Stockholm, Sweden; The Loo and Hans Ostermans Foundation for Geriatric Research, Stockholm, Sweden; Meda Sverige AB, Göteborg, Sweden; Nutricia Nordica AB, Stockholm, Sweden; Pharmacia & Upjohn AB, Uppsala, Sweden; The Swedish Association of Health Professionals, Stockholm, Sweden; The Swedish Nutrition Foundation, Lund, Sweden; The Swedish Nutrition Network for Nurses, Stockholm, Sweden; The Swedish Society of Nursing, Stockholm, Sweden; 3M Svenska AB, Sollentuna, Sweden.

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Appendix

REGION SKÅNE

Food and Fluid Chart

Nutrition Chart 2001 Region Skåne, Sweden

TRANSLATED FROM SWEDISH

Date: ....

Type of diet: ....

Portion size: ....

Name:

ID#:

Ward:

Food intake

Time	***Breakfast***		Served amount	Eaten amount	kcal
	Porridge, kind:	dl			
	Eggs				
	Sandwich	#			
	Sugar, granulated	tbs			
	Sugar, lumps	#			
	Jam/Fruitpurée	tbs			
	Lunch/Dinner Main dish	portion size	1/1 3/4 1/2 1/4	1/1 3/4 1/2 1/4 0	
	Porridge, kind:	dl			
	Hot soup	dl			
	Sandwich	#			
	Dessert, kind:				
	Supper/Evening meal Main dish	portion size	1/1 3/4 1/2 1/4	1/1 3/4 1/2 1/4 0	
	Porridge, kind:	dl			
	Hot soup	dl			
	Sandwich	#			
	Dessert, kind:				
	Snack between meals				
			Sum food chart (kcal)		

Fluid intake chart

Time	Drinks	Served amount mL	Eaten amount mL	kcal
↑	*Enteral Tube Feeding Formulas - begin at the bottom*			
Sum enteral tube feeding formulas (mL/kcal)				
Sum other enteral tube feeding fluid (mL/kcal)				
Sum fluid chart (mL/kcal)				
			→	
Total				

Fluid losses

Time	***Urine*** mL	***Vomit*** mL	***Diarrhoea*** mL
Sum			
Time	mL	mL	mL
Sum			

Energy Contents Guide

TRANSLATED FROM SWEDISH

Sandwiches, bread and butter	*amount*	*kcal*
Sandwich (open), bread and margarine with cheese/ham	1 ea	150
Crispbread and margarine with cheese/ham	1 ea	110
Crispbread	1 pce	40
Slice of bread	1 pce	60
Spreading fats, soft low fat margarine, 40% fat	1 portion/10 g	30
Spreading fats, soft regular margarine, 80% fat	1 portion/10 g	70
Beef meat	1 slice/10 g	20
Cheese	1 slice/15 g	40
Ham, boiled/smoked	1 slice/20 g	20
Liver paste, soft cheese, soft whey-cheese	1 portion /15 g	40
Sausage (mettwurst), boiled/smoked (polony)	1 slice/10 g	40
Porridge, Eggs, Sugar and Jam		
Corn Flakes	1 dl	50
Eggs	1 ea	80
Herring, pickled	1 small slice/10 g	20
Jam, Apple-sauce, Honey	1 tbs	60
Jam unsweetned	1 msk	20
Linseed, dried	1 tbs/10 g	40
Müsli, plain	1 dl	140
Porridge, cooked on water, like oatmeal porridge	1 dl	50
Porridge, cooked on milk, like semolina pudding	1 dl	100
Porridge, childrens porridge (powdered-based)	1 dl	100
Prunes	1 pce/5 g	10
Sugar, granulated	1 tbs	60
Sugar, lump	1 lump/3 g	10
Wheat bran	1 tbs/5 g	10
Lunch / Dinner / Supper		
Regular main hot meal including meat/fish, potatoes/rice, vegetables, sauce/jam	1/1 port	440
	3/4 port	330
Please contact the dietian or the kitchen about the energy contents of modified diets.	1/2 port	220
	1/4 port	110
Baby Foods (Savoury dishes)	100 g/1 dl	90
Fresh fruit		
Apple, Orange, Peache, Pear	1 ea/150 g	80
Apricot, Clementine, Kiwi fruit	1 ea/70 g	30
Banana	1 ea/100 g	100
Blueberries, Cherries, Currants, Gooseberries	1 dl/60 g	30
Plums	1 ea/35 g	20
Grapes	1 dl/70 g	50
Raspberries, Strawberries	1 ea/60 g	30

Desserts	*amount*	*kcal*
Apple cake with sauce, Swedish Cheesecake with jam, Pancakes 2 pce with jam, Waffle 1 pce with jam	1 portion/2 dl	250
Fruitpurée (tinned baby food)	100 g/1 dl	80
Ice cream, low fat	1 tub/65 g	70
Ice cream, regular	1 tub/65 g	150
Stewed fruit, Tinned fruit, Fruit salad	1 portion/2 dl	100
Cakes, Cookies, Pastries and Sweets		
Biscuits, Gingerbread biscuit	1 ea/5 g	30
Cakes, Sponge cake, Swiss roll	1 slice/30 g	120
Candy, Caramels, Sweets, Toffees	1 ea/5 g	20
Cookies, Shortbread	1 ea/10 g	50
Confectionary bars, Danish pastries, Éclair	1 st/ca 50 g	200
Milk chocolate, Wafers filled coverd with milk chocolate	100 g	550
Pastries, Gateau, Whipped cream layer cake	1 slice/110 g	320
Rusks *(1 rusk with spreading fats= 50 kcal)*	1 ea/10 g	40
Sweet wheat bread plain (coffe-cake)	1 slice/25 g	80
Sweet wheat bread buns (coffe-cake)	1 st/ca 50 g	150
Sweet wheat bread filled (coffe-cake)	1 slice/30 g	100
Wafer plain *(Dubble wafer with spreading fats = 30 kcal)*	1 st/ca 2 g	10
Dairy products		
Fermented milk, skim, very low fat 0.5%	100 mL	40
Fermented milk, fat 3%	100 mL	60
Fruit yoghurt, fat 2.5%	100 mL	90
Fruit yoghurt, skim, very low fat 0.5%	100 mL	70
Cream coffe fat 12%, Sour creame *(1 tbs = 20 kcal)*	100 mL	130
Fermented milk, low fat 1.5%	100 mL	50
Milk, skim, very low fat 0.5%	100 mL	40
Milk, fat 3%	100 mL	60
Whipping cream, not whipped *(whipped: 1 tbs = 30 kcal)*	1 tbs	60
Beverages and Soups		
Beef tea	100 mL	10
Beer (light/small bear)	100 mL	30
Coffe, tea *(don't forget sugar, cream/milk)*	100 mL	0
Dessert soup, Fruit-syrup soup, Rose hip soup	100 mL	50
Fruit fool/jelly	100 mL	90
Fruit juice	100 mL	50
Gruel	100 mL	70
Milk chocolate drink	100 mL	80
Soft drinks, Carbonated beverages *(not light products)*	100 mL	40
Soft drinks unsweetned	100 mL	20
Soup, dessert soup, enriched (liquid diet)	100 mL	100
Soup, dinner soup, enriched (liqued diet)	100 mL	120
Soup, dinner soup *(not pea soup with pork)*	100 mL	60
Wine	100 mL	70
Dessert wine, Spirits	1 cl (10 mL)	20

Dietary Supplements, Industrial made Oral Drinks:

- local brand names

Dietary Enrichment and Supplement Powders and Liquid Thickening Powders:

- local brand namnes

Enteral Tube Feeding Formulas and Parenteral Nutrition Solutions:

- listed seperatly

Standard Measures*	*amount*
Coffee-cup, large	150 mL
Coffee-cup, small	125 mL
Disposable glass/cup, small	75 mL
Disposable glass/cup, large	150 mL
Drinking-glass (tumbler), normal	175 mL
Drinking-glass (tumbler), small	150 mL
Feeding cup	225 mL
Soup plate	250 mL
Tablespoon (tbs)	15 mL
Teacup, large	275 mL
Teaspoon (tsp)	5 mL

(100 mL = 1 dl = 0,1 liter)

**NOTE: Standard measures commonly used in Swedish hospitals. The measures can vary depending on the kind of service set used. The amounts indicated above refer to cups and glasses filled up to 1 cm from the rim.*

NOTE: The energy numbers (calorie content of serving) listed above are approximated values to make the adding easier.

I

Error	Correction
Page 853: Table 2, kolumn Mean	
Cobalamin (µg) 2.0±0.4	2.0±0.9
Calcium (mg) 820 ±230	821 ±230
Page 853: Table 2, kolumn Women	
Asorbic acid (mg) 53 ±25.5	53 ±25.2
Page 853: Table 3	
Energy balance (kcal) -502 ±535	-502 ±536
Page 854: References	
Cooper C., Wickham C. & Walsh K (1988) Appendicular skeletal status and hip fracture in the elderly: 14 years prospective data. British Medical Journal 297, 1443-1446.	(1991) Bone 12, 361-364.

Journal of Advanced Nursing, 1997, **26**, 851–855

Malnutrition in geriatric patients: a neglected problem?

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Accepted for publication 1 October 1996

ELMSTÅHL S., PERSSON M., ANDRÉN M. & BLABOLIL V. (1997) *Journal of Advanced Nursing* **26**, 851–855

Malnutrition in geriatric patients: a neglected problem?

The nutrient intake in geriatric long-stay patients and the mortality risk associated with low energy intake were studied in 61 patients, 43 women and 18 men, with a mean age of 87 years, at a geriatric long-stay care hospital during a 6-month follow-up. Dietary intake was assessed with a 9-day dietary record. Energy expenditure was calculated assuming a physical activity level of 1·33 × basal metabolic rate (BMR), predicted from equations given by FAO/WHO. Mean energy intakes were 1557 kcal in men and 1280 kcal in women; 84% of the patients had an intake below estimated energy expenditure and 30% were below estimated BMR. Only 5% received dietary supplement. Eleven out of the 61 patients died during the follow-up and the deceased had lower energy intake than the others (1185 kcal vs 1401 kcal, $P<0{\cdot}05$). An energy intake below median (1378 kcal) was associated with an age adjusted increased 6-month mortality risk, odds ratio 12.5. A high proportion of geriatric long-stay patients report dietary intake far below present recommendations and are thereby at risk for having/developing malnutrition. Improved surveillance of geriatric long-stay patients' dietary habits seems justified.

Keywords: diet, malnutrition, mortality, nursing

INTRODUCTION

A high prevalence of malnutrition in elderly patients admitted to different clinical settings, of the order of 20–50%, has been reported from several studies during recent decades (Bistrian *et al.* 1976, Elmståhl 1987, Volkert *et al.* 1992, Larsson *et al.* 1990). Prolonged protein-energy malnutrition (PEM) is also associated with deterioration of immune function, anthropometric changes and increased morbidity and mortality (Chandra *et al.* 1982, Cederholm 1994, Potter *et al.* 1995). Mortality at 9 months more than doubled in non-malignant malnourished

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patients admitted as emergency cases, about 44%, compared to non-malnourished patients (Cederholm 1994). Hospitalization *per se* has also been shown to cause deterioration of nutritional status in geriatric patients (Elmståhl 1987, Larsson *et al.* 1990).

A number of causes of PEM have been identified, including medical, social and environmental causes. Different medical conditions can change metabolism, absorption or cause excessive nutritional losses, and dietary intake can be impaired by psychiatric disorders and functional incapability due to movement disorders or swallowing problems (Elmståhl *et al.* 1987). The hospital environment can also be important for adequate intake in nursing homes and hospitals. Appropriate hospital meals includes organization of the meal times during the day, prepared dishes adjusted for patients with denture or swallowing problems, serving aides for disabled patients, sufficient time for the staff to help dependent patients and an attractive *milieu* at meal time. These are all factors which have been shown to substantially influence dietary intake (Elmståhl *et al.* 1987, Morley *et al.* 1995).

Although the underlying cause of protein-energy malnutrition cannot always be treated, the effect and symptoms of malnutrition can to some degree be prevented or reduced if subjects with poor nutritional status are identified. This can be achieved by monitoring weight changes, food intake or anthropometric and laboratory data depending on the medical condition. Enteral treatment and support with dietary supplement have been shown to reduce morbidity, mortality and length of hospital stay in elderly patients (Delmi *et al.* 1990). The aim of the present study was to investigate the occurrence of low dietary intake, dietary habits and any association with mortality at a 6-month follow-up using a dietary record as a screening instrument.

METHODS

Two long-stay wards of a geriatric unit in the city of Malmö were studied. Sixty-one out of 67 geriatric long-stay patients were included in the study, 43 women and 18 men. Mean age was 86·6 years (range 56–103). Six patients were excluded from the study including, one patient who died during the diet assessment period, one patient who was discharged from the ward and four terminal bedridden patients with unstable medical conditions, according to the physician and registered nurse. Table 1 presents the main diagnosis according to medical records and body weight.

Dishes were prepared in the central kitchen of the hospital and delivered to the wards in canteens and food was prepared according to the Swedish nutrient recommendations with a mean daily energy content of 2000 kcal. The dietary intake was assessed using a 9-day dietary record during May 1995; 7 working days and two holidays were randomly selected. Two nutritionists (MA and VB) were responsible for the assessment and instructions to the ward staff. Four standardized portion sizes were used for the main dishes (1, ¾, ½ and ¼ size) as well as standardized household measurements taking into account food left over. Snacks and items given by relatives were also registered. Nutrient calculation of recipes, served dishes from the central kitchen and dietary supplements were made using a nutrient calculation program (Kostsvar, AIVO, Stockholm, Sweden). Data were coded using the Swedish Food Database prepared by the National Food Administration (1989) which provides data on the nutrient content of about 1500 food items, beverages and recipes (Food Composition Tables, 1988). Basal metabolic rate (BMR) was predicted using the equations given by FAO/WHO/UNU (World Health Organization 1985). Energy expenditure was calculated assuming a physical activity level of 1·33 times BMR for both sexes, corresponding to a sedentary life for indoor subjects without daily physical activity. None of the included patients were bedridden.

Table 1 Descriptive data on geriatric long-stay patients

	Men	Women	Total
Number	18	43	61
Age	83·4 ± 9·5	87·9 ± 6·7	86·8 ± 7·8
Diagnosis (%)			
Dementia	6 (33)	18 (42)	24 (39)
Cerebrovascular disorder	4 (22)	8 (19)	12 (20)
Cancer	5 (28)	0 (0)	5 (8)
Cardiovascular disorder/ Other disorders	3 (17)	17 (39)	20 (33)
Body weight (kg)	69·3 ± 12·2	53·4 ± 11·1	58·1 ± 13·5

Statistics

Student's *t*-test was used to analyse differences between groups. Cox regression analyses were performed to examine differences in energy intake with survival time as the dependent variable.

RESULTS

Table 2 shows that about 80% of men and women had low energy intake and more than half of them had intakes of vitamin D, ascorbic acid, iron and cobalamine below present recommendations. Eighty-four per cent of the patients had an energy intake below estimated energy expenditure, and 35% of the women and 17% of the men had an energy intake below estimated BMR. Separate analyses of energy intake or energy balance in the 16 patients with Alzheimer's dementia compared to other dementia types or other disorders showed no differences.

Table 2 Mean daily intake of energy and nutrients, and energy expenditure in geriatric long-stay patients (18 men and 43 women). Percentage of subjects *below* Swedish nutrient recommendations (SNR) are given within brackets

	Men Mean (SD)	Women Mean (SD)	Total Mean (SD)	SNR levels Men/women
Energy (kcal)	1557±230 (83)	1280±307 (81)	1362±312	1800/1500
Protein % energy	17±1 (22)	17±3 (21)	17±2 (21)	15%
Fat % energy*	28±4 (22)	29±10 (18)	29±16 (20)	30%
Carbohydrates % energy	50±4 (94)	52±6 (77)	51±5 (85)	55%
Thiamin (mg)	1·2±0·4(33)	0·9±0·3 (51)	1·0±0·3 (48)	1·0
Cobalamine (μg)	2·0±0·4 (89)	2·0±0·9 (86)	2·0±0·9 (87)	3·0
Asorbic acid (mg)	65±19·9 (67)	53±25·5 (72)	56±24·2 (62)	60
Vitamin D (μg)	2·6±1·1 (100)	2·4±1·4 (100)	2·5±1·3 (100)	10
Calcium (mg)	820±230 (17)	806±252 (53)	810±244 (43)	600/800
Iron (mg)	9·5±1·7 (50)	7·9±2·6 (84)	8·3±2·5 (74)	10
Energy expenditure (kcal)	1790±269	1607±200	1661±236	
Energy balance (kcal)	−232±240	−327±367	−299±336	

* Number of subjects *above* the recommendation of 30% energy intake as fat.

Table 3 shows that the 11 patients who died during the 6-month follow-up had significantly lower energy and protein intake and a negative energy balance compared to those alive 6 months later. None of the deceased used dietary supplements. The diagnoses of these patients were: dementia, 7 cases; cancer 3 cases; and cerebrovascular disease in 1 case. The proportion of dementia disorders and cerebrovascular disease did not differ between the groups, but three (27%) of the deceased had a cancer diagnosis compared to two (4%) among the alive patients (chi-square test, $P=0.05$). However, if these five patients with a diagnosis of cancer were excluded from the analyses, the above mentioned differences with lower energy intake and negative energy balance among the deceased remained (1130 kcal vs 1384 kcal, $P<0.05$; and −270 kcal vs −589 kcal; $P<0.05$, Student's test). A logistic regression analysis with respect to an energy intake below median (1378 kcal) was associated with an increased 6-month mortality risk, OR=12.5 (C1 90% 1·9–71·4) adjusted for age and cancer.

Table 3 Intake of energy and nutrients and energy expenditure in geriatric long-stay patients who were deceased or alive 6 months after dietary assessment. Student's test with *P*-values

	Deceased	Alive	*P*-value
Number	11	50	
Energy	1185±380	1401±284	0·04
Protein (g)	48±17·7	58±14·1	0·05
Fat (g)	37±15·9	44±17·1	0·23
Carbohydrates (g)	149±45·2	173±36·5	0·06
Thiamin (mg)	0·8±0·4	1·0±0·3	0·07
Cobalamine (μg)	1·6±0·8	2·1±0·9	0·11
Asorbic acid (mg)	66±23·0	54±24·2	0·15
Vitamin D (μg)	2·9±2·1	2·4±1·0	0·25
Calcium (mg)	772±305	819±231	0·57
Iron (mg)	7·4±3·0	8·5±2·4	0·18
Energy expenditure (kcal)	1687±212	1655±242	0·70
Energy balance (kcal)	−502±535	−254±261	0·03
Body weight kg)	60·8±11·8	57·5±13·9	0·47
Age	87·5±5·9	86·4±8·2	0·68

A Cox regression analysis with survival time as the dependent variable and log-transformed energy intake as the independent variable, adjusted for age, cancer (yes/no) and dementia (yes/no), showed that higher energy intake was related to a decreased risk of mortality; RR=0·06 (95% confidence interval: 0·01–0·56).

Food with normal consistency was served to 56% of all patients; 31% received minced dishes, 7% had a liquid diet and 6% had a restricted diet because of diabetes mellitus. Only 5% of all patients received any dietary supplements during the assessment. The energy intake between patients with normal consistency and patients with liquidized diet or minced diet did not differ (1323±231 kcal vs 1454±231 kcal).

DISCUSSION

A high prevalence (84%) of the geriatric long-stay patients had an energy intake below estimated energy expenditure, and 30% of the patients had an intake below estimated BMR. Eighteen per cent of the patients died within 6 months and the deceased had a lower energy intake at baseline than the others (1185 kcal vs 1401 kcal). However, the body weight and the estimated energy expenditure among the deceased was higher than the others. This might indicate that the poor nutritional intake *per se* was related to the increased mortality and not only an underlying disease causing poor nutritional intake and increased

mortality. These results were similar to a prospective case-control study of 501 geriatric patients admitted to long-term care. In that study the mortality of initially well-nourished patients was 9% among those given dietary supplements compared to 19% in the group without supplementation, after 6 months (Larsson *et al.* 1990).

The nutrient intake was calculated using a 9-day dietary record with standardized portion sizes. The nutrient calculations have taken into account the temperature dependent losses of vitamin C and thiamin during cooking and afterwards, including 30 minutes delay from the central kitchen to the wards. Since the delay to the wards could be more than 30 minutes, the available vitamin C and thiamine could be considerably lower than calculated values. The dietary record also included consumption outside the wards and supplements.

Malnutrition is a condition with an imbalance between intake and needs of specific nutrients. Chronically disabled elderly inpatients at hospitals and nursing homes often display a combination of energy-protein malnutrition and low intakes of several fat- and water soluble-vitamins due to low food intake (Elmståhl *et al.* 1987, Bienia *et al.* 1982, Pinchofsky-Devin & Kaminski *et al.* 1987). In this paper no attempt was made to define conditions with PEM according to commonly used definitions including biochemical and anthropometric variables. However, long-standing energy intake below estimated needs will not be compatible with long-term health and well-being. Since a high proportion (30%) showed energy intake below estimated BMR it could be assumed that they were at risk of being malnourished. This group also showed an increased mortality.

Energy balance as defined by using predicted BMR values and actual body weight will not take into account whether the estimated expenditure allows for a desirable level of physical activity. The estimated energy expenditure values cannot differentiate between individual differences in physical activity and the results should, therefore, be interpreted on a group level. A physical activity level of 1·33 was used in this study which corresponds to a very sedentary life with little physical activity. However, geriatric long-stay patients show a great inter-individual variation in energy expenditure. In a previous study, energy expenditure was estimated with heart rate monitoring and oxygen consumption and the range of energy expenditure was between 1220 kcal and 2334 kcal for men (mean 1845 kcal), and between 1039 kcal and 2567 kcal for women (mean 1550 kcal) (Elmståhl 1987). Thirty per cent of those geriatric long-stay patients had an energy intake below the 95% confidence limits of their expenditure (Elmståhl 1987). Therefore, the estimated energy expenditure in this study might be too low using a sedentary level of physical activity, since none of the patients were bedridden.

Adequate intakes of vitamin D and calcium are important to avoid osteoporosis. This is especially important for geriatric long-stay patients with insufficient sunlight exposure. Increased rates of fractures have been reported in prospective studies of elderly people with depletion of vitamin D and calcium (Cooper *et al.* 1988, Holbrook *et al.* 1988). In this study the estimated intake of vitamin D was low, only 2·5 microgram. The calcium intake exceeded the present Swedish recommended intake for most men (600 mg) and for about half of the women (800 mg), but there is an ongoing discussion whether the recommended levels are sufficient or not (National Institute of Health 1994).

A variety of medical, social and environmental causes, solely or together, might induce malnutrition. Elderly hospitalized patients with cognitive deterioration and functional disabilities will have an increased need of assisted feeding (Siebens *et al.* 1986). During hospitalization ritualized practices of the serving procedures and meal situation will also inevitably reduce individual needs (Sidenvall *et al.* 1994). Sustained malnutrition will increase mortality risk and previous studies have shown that dietary supplements can improve dietary intake substantially and also reduce mortality (Larsson *et al.* 1990, Delmi *et al.* 1990, Elmståhl & Steen 1987). None of the patients with dietary supplements in this study belonged to the deceased group.

In conclusion, many geriatric long-stay patients have energy and nutrient intake far below present recommendations. A higher mortality was found among those with lower energy intake, independently of diagnosis. Improved nutritional surveillance among geriatric long-stay patients is needed.

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II

Error	Correction
Page 16: Population, line 14 (56 women and 21 men)	25 men
Page 18: Table 2 Energy, column “r” for Men	the letter “P” should be omitted
Total water (g)	Water (g)

Clinical Nutrition (2002) **21(1)**: 15–25

doi:10.1054/clnu.2001.0497, available online at http://www.idealibrary.com on IDEAL®

ORIGINAL ARTICLE

The reproducibility of a new dietary record routine in geriatric patients

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Abstract—Background and aim: Malnutrition in nursing home residents is an important clinical and public health problem. Knowledge is lacking about the reproducibility of dietary recording in geriatric patients. Few studies have described water intake in this age group. The aim of this study was to test the reproducibility of a 7-day dietary record routine in a clinical setting. *Methods*: The dietary intake of 81 geriatric patients was recorded for two discrete periods of 7 consecutive days by the ward staff. The dietary record routine, which assessed both food and fluid intake, was based on standardized portion sizes and household measurements. *Results*: The mean daily energy intake during the first period was 7.07 MJ and 6.84 MJ during the second period, with a mean difference of 4%. Corresponding values and the mean difference for water intake from food and beverages were 1781 g, 1702 g and 4% respectively. Age, gender, diagnosis, length of stay, diets or ADL function did not influence the results. The correlation coefficient for fluid intake between the periods was 0.84 for women and 0.72 for men. *Conclusion*: The 7-day dietary record routine seems to have a good reproducibility in assessing the intake of energy and fluids in geriatric patients. © 2002, Elsevier Science Ltd. All rights reserved.

Key words: malnutrition; aged; reproducibility; diet records; energy intake; drinking

Introduction

Malnutrition in nursing home residents is an important clinical and public health problem. One important factor contributing to its prevalence appears to be the failure of health care professionals to recognize its signs and identify patients with malnutrition or at risk of becoming malnourished (1–3). Several studies have shown that patients with malnutrition are not diagnosed correctly (1–3) and that the documentation in medical and nursing records is insufficient (2, 4, 5). A high rate of malnutrition in elderly patients has been noted in various clinical settings by many investigators over the last few decades (6, 7) and is accompanied by a high mortality rate (8–10). In a recent study of a novel dietary record routine for nursing home patients (10), investigators found that the energy intake was less than the calculated energy expenditure for 84% of the patients and that 30% of the patients had an intake below the estimated basal metabolic rate.

Various methods of assessing dietary intake can be used to identify malnutrition and patients at risk of becoming malnourished (11, 12). Retrospective methods include dietary history, food frequency questionnaires and 24-hour recall, whereas prospective methods include the use of dietary records and duplicate meals. Assessment of the dietary intake of hospitalized patients can either be self-administered by the patient's (13) or observed by the staff (14). Sometimes the observation method is not designed to cover a complete 24-hour period but only to assess the intake at major meals (15). The method of choice for the collection of food consumption data and for monitoring nutritional status in geriatric patients is the staff-administered dietary record (11), because the findings are not influenced by the various kinds of illness and levels of cognitive impairment that are common in this population. Due to intra-and interpersonal variations, food and fluid intake must be recorded for several days before the patients' intakes can be classified (11, 16, 17). Self-administered estimated dietary intake records have been used in large studies in the community (18–20) and even in studies of the elderly (21).

The reproducibility of assessing the dietary intake is the ability of an instrument to produce the same results on two or more different occasions under the same conditions and assuming that nothing has changed between the occasion's (11). Numerous studies have used dietary records as the reference method in validating 24-hour recalls, diet history and food frequency charts (11, 22, 23). Most studies on the reproducibility of food records have been using weight records in younger free-living subjects. Only a few studies have been published on the reproducibility of estimated dietary records (24–26). We have not been able to find any published reproducibility study of

an estimated dietary record assessing both energy and fluid intake in geriatric patients where the staff has done the recording.

Little attention has been paid to the reproducibility of dietary methods of assessing fluid intake. However, this is important area because the elderly have a diminished sensation of thirst and are less able to regulate their fluid balance (27, 28). If left untreated, dehydration can result in death in many cases (29, 30). Dehydration is poorly defined and its clinical signs can be vague, especially in the elderly (31, 32).

The aim of this study was to test the reproducibility of a 7-day observed estimated dietary record routine with standardized portion sizes and household measuring in a real world clinical setting. The dietary record routine, which assesses both food and fluid intake, has been adapted for use by the ward staff in a real world clinical setting. The newly developed dietary record routine has been used in a previous study (10) and is intended to be used in further studies as a screening instrument to detect geriatric patients at risk of developing malnutrition.

Material and methods

Population

The study population of 81 geriatric patients was recruited from five Swedish nursing home wards. Inclusion criteria were nursing home residence and the ability to ingest food and fluid. Exclusion criteria were parenteral or enteral nutrition, acute illness during the periods just prior to or during the study, or terminal conditions, i.e. where death was expected in a short while. A total of 102 patients from the wards matched the study criteria and agreed to participate. However, data were not obtained for 21 (13 women and 8 men) of the 102 patients: 13 were excluded before or during the diet recording due to acute illness and 8 died before any diet recording was done. Thus, the study group consisted of 81 patients (56 women and 21 men) with a mean age of 85 years (SD $\pm$ 7.8 years; range 58–97 years). The mean length of stay at the wards was 752 days (SD $\pm$ 612 days; range 66–2871 days). The most common diagnoses were dementia 33%, stroke 27%, orthopaedic disorders 10%, neurological disorders 7% and cancer 4%. Most of the patients had multiple medical diagnoses; 38% had dementia and 31% had stroke among their multiple diagnoses. A total of 68% of the patients scored an F or G on the Katz ADL index (33, 34), indicating that they were highly dependent on others in their activities of daily life (ADL). A total of 21% of the patients were dependent for all activities. Only 10% of the patients were highly independent, as indicated by scores of A or B, and the remaining 22% of the patients had Katz ADL index scores of C, D or E. The mean body weight was 52.6 kg (SD $\pm$ 9.4 kg; range 35.5–76.1 kg) for women and 66.9 kg (SD $\pm$ 11.7 kg; range 43.0–97.5 kg) for men. The mean body mass index (BMI) was 21.5 (SD $\pm$ 4.1; range 14.8–32.4) for women and 23.0 (SD $\pm$ 4.6; range 15.8–35.4) for men. Of the 81 patients 58% had a BMI between 20 and 30, 38% had below 20 and only 4% had a BMI above 30.

Table 1 Criteria for protein energy malnutrition and cut-off levels

Variables	Normal value	Low value
Weight index (%)	>80	≤ 80
Triceps skinfold (mm)		
women 70–79 years	>13	≤ 13
women >79 years	>10	≤ 10
men 70–79 years	>6	≤ 6
men >79 years	>6	≤ 6
Arm muscle circumference (cm)		
women 70–79 years	>19	≤ 19
women >79 years	>18	≤ 18
men 70–79 years	>22	≤ 22
men >79 years	>21	≤ 21
Serum albumin (g/L)	>36	≤ 36
Serum prealbumin (g/L)		
women	>0.18	≤ 0.18
men	>0.20	≤ 0.20

Cut-off points according to Swedish norms (53, 54).
A low value for three or more variables is an indicator of protein energy malnutrition (PEM).

Blood samples were taken to measure albumin, prealbumin, haemoglobin, triiodothyronine, thyroid-stimulating hormone, prothrombin and orosomucoid by standard routines at the Division of Clinical Chemistry, Malmö University Hospital. Protein-energy malnutrition (PEM) was defined by biochemical and anthropometric criteria (Table 1). Of the 81 patients 28% met the criteria for PEM.

Dietary intake

Before the study period started, the ward staff attended a 2-hour training session on taking dietary records, conducted by the authors (MP and VB). The training consisted of oral and written information on the dietary record routine and practical training in assessing portion sizes using both real dishes and photographs of different dishes. During the study period, the ward staff were provided with written information on the recommended portion sizes and with photographs of different portion sizes, but received no direct assistance from the investigators other than having their questions answered. The record-keeping staff, which consisted of registered nurses, practical nurses and nurse assistants, was instructed not to alter any routines during the study.

Dietary intake was recorded for 7 consecutive days and then again for another 7 consecutive with a time gap between the two periods. The median time gap between the periods was 21 days (6–42 days). The recording was done between March and May ($n=48$) and between November and December ($n = 33$) and there were no major holidays in any of the recording periods. The ward staff did all dietary recording and individual charts were maintained daily. The record form is a newly

developed estimated dietary record form for use in clinical settings and is designed to be as self-explanatory as possible. It is in A4 size and has two pages. The front page (Appendix 1) is for individual dietary recording over a 24-hour period and the back page (Appendix 2) gives information about the energy content of some 100 food items that are common in a hospital setting.

Standardized portion sizes using the quartile method (0, 1/4, 2/4, 3/4, 1/1) were used for lunch and dinner; breakfast, snacks, and beverages were assessed separately using household measuring devices. Nutrient intake was calculated using a nutrient computer software program (AIVO Kostplan 1.25, Sweden 1997, and Food Composition Table from Swedish PC-kost, December 1997). The food was prepared by the hospital kitchen staff and was served by the ward staff. The recipes from the hospital kitchen were used to calculate the energy and nutrient content of each meal. Swedish norms for the mean weight and/or volume of different food items and portion sizes were used for consumed snacks and beverages consumed (35, 36). The utensils used on the wards were calibrated by volume. Dietary records were coded by one of the authors (MP) and then checked independently by an experienced clinical dietitian (VB) in order to avoid coding errors.

Fluid intake was calculated from all consumed beverages. Water intake was calculated, using food composition tables, from the combined intake from fluids and from food items. Out of the 81 patients, 73% were given a regular diet, while 27% were given pureed foods. Only 3% of the patients received food supplements on a daily basis and 12% of the patients received food supplements at some time during the study period.

Ethics

Each patient and/or a close relative gave an informed consent to the patient's participation in the study. The study was approved by the Local Ethical Committee at Lund University, Sweden.

Statistics

Statistical analyses was performed using SPSS for Windows computer software (9th edn Chicago, SPSS Inc; 1999). Values are expressed as means and standard deviations (SD). In the sub-group analysis (Tables 3 and 5) the variables age, length of stay and BMI was divided by the median value and the weight index was set at 80%, in accordance with the criteria for PEM (Table 1). Non-parametric methods were used when analysing data as the samples were small and were not normally distributed (37). The relationship between periods 1 and 2 was examined using the two-tailed Spearman's rank correlation coefficient. The cross-classification by tertiles was examined using the χ^2 test. The sub-group analysis (Tables 3 and 5) was examined using the Mann–Whitney test. The Kruskal–Wallis test was used for the items *ward* and *diagnosis*. Results were considered statistically significant if *P*-values were less than 0.05.

Results

Energy and nutrients

The mean daily energy intake during the first registration period was 7.07 MJ (SD $\pm$1.40 MJ) and 6.84 MJ (SD $\pm$1.32 MJ) during the second period, with a mean difference of 4%. The corresponding values for the periods for women were 6.70 MJ (SD 1.28 MJ) versus 6.43 MJ (SD 1.24 MJ) 5%, and for men 7.89 MJ (SD $\pm$1.32 MJ) versus 7.77 MJ (SD $\pm$0.99 MJ) 2%. Data for other nutrients are given in Table 2. Spearman's correlation coefficients between measurements varied for most nutrients between 0.7 to 0.9 for women and between 0.6 and 0.9 for men (Table 2).

The difference between energy intake during the first and the second period (ΔE) and the relative difference (ΔE%) were examined in relation to gender, age, length of stay, diagnosis, body weight, weight index, diet, ADL independence, PEM and nursing home ward. Statistically significant differences were only noted for weight index, BMI and nursing home ward (Table 3). Energy intake in relation to reduced eating ability, defined as Katz index level G (21%), did not differ between periods. Cross-classification of energy intake during period 1 compared to period 2 by tertiles shows that 75% of the patients were classified correctly and only 2% were grossly misclassified by more than one tertile (Table 4) and Kendall's τ-value was 0.72.

Water and fluid

The mean daily water intake from food and beverages was 1781 g (SD $\pm$334 g) during the first period compared to 1702 g (SD $\pm$ 291 g) during the second period with a mean difference of 4% (Table 2). The relative differences between the periods were 5% for women and 2% for men. The mean daily fluid intake was 1251 mL (SD $\pm$272 mL) during the first period compared to 1194 mL (SD $\pm$256 mL) during the second period with a mean difference of 6%. Individual values of the daily mean water and fluid intake during the two periods are given in Figure 1.

The difference between daily water intake during the first and the second period (ΔW) and the relative difference (ΔW%) in relation to gender, age, length of stay, diagnosis, body weight, diet, ADL independence, PEM and nursing home ward are given in Table 5. Statistically significant differences were only noted for weight index, PEM and nursing home ward. Cross-classification of daily water intake during period 1

Table 2 Dietary intake during period 1 and 2 for women ($n=56$) and men ($n=25$) separately. Values are given as daily mean intake and SD ($\pm$). Spearman's correlation coefficients (r) are given and P-values are given as * = $P<0.05$, ** = $P<0.01$ and *** = $P<0.001$

	Women			Men		
	Period 1	Period 2	r	Period 1	Period 2	r
Energy (kcal)	1601±305	1537±295	0.83***	1885±316	1857±237	0.61**P
Energy (MJ)	6.7±1.3	6.4±1.2	0.83***	7.9±1.3	7.8±1.0	0.61***
Protein (g)	59.2±14.5	57.3±13.3	0.83***	71.0±14.5	69.3±11.5	0.68***
Fat (g)	54.0±13.5	51.8±12.6	0.85***	63.3±12.6	63.1±11.5	0.68***
Carbohydrates (g)	214.3±41.2	205.4±43.5	0.83***	247.6±41.6	243.8±30.4	0.51**
Alcohol (g)	1.8±3.0	1.7±2.7	0.92***	4.3±4.1	3.8±4.0	0.89***
Dietary fiber (g)	11.9±2.9	11.4±3.2	0.84***	15.2±3.9	15.1±3.2	0.55**
Vitamin A (μg)[1]	841.9±401.0	736.0±267.9	0.71***	878.3±404.9	819.9±237.1	0.42*
Vitamin D (μg)	2.5±1.2	2.3±1.0	0.89***	3.2±1.0	3.0±1.0	0.75***
Thiamin (mg)	1.2±0.3	1.2±0.3	0.78***	1.4±0.4	1.4±0.3	0.85***
Riboflavin (mg)	1.5±0.4	1.4±0.3	0.84***	1.7±0.4	1.7±0.4	0.80***
Niacin (mg)[2]	23.4±6.2	22.3±5.5	0.77***	29.0±6.3	28.2±5.6	0.66***
Vitamin B6 (mg)	1.3±0.3	1.3±0.4	0.80***	1.7±0.4	1.7±0.4	0.59**
Folate (μg)	163.6±57.7	148.1±49.3	0.82***	191.1±65.6	181.6±51.3	0.70***
Vitamin C (mg)	77.0±52.6	71.3±50.2	0.82***	80.8±56.3	75.7±51.2	0.87***
Calcium (mg)	1018±254	996±256	0.89***	1109±270	1094±242	0.83***
Iron (mg)	6.1±1.8	5.8±1.7	0.78***	7.5±1.8	7.4±1.6	0.44*
Total water (g)	1702±291	1631±273	0.81***	1958±362	1925±290	0.67***
Fluid (mL)	1246±276	1179±266	0.84***	1263±266	1228±232	0.72***

[1]Vitamin A is given in retional equivalents.
[2]Niacin is given in niacin equivalents.

Table 3 Data for period 1 ($P1$) and ($P2$) are given for mean daily energy intake (EI), energy intake per kg of body weight (EI/BW) and absolute differences (ΔE) and relative differences (ΔE%). Significant differences *between periods* are given as letters: a = $P<0.05$, b = $P<0.01$ and differences *within items* as: * = $P<0.05$

		EI (kcal/day)		ΔE (kcal)	ΔE% (%)	EI/BW (kcal/kg BW)		ΔE/BW (kcal/kg BW)	ΔE%/BW (%)
		$P1$	$P2$	$P1-P2$	$P1/P2$	$P1$	$P2$	$P1-P2$	$P1/P2$
All	($n=81$)	1688	1636a	53	4	31	29a	1.2	4
Gender	Women ($n=56$)	1601	1537a	64	5	31	30b	1.4	5
	Men ($n=25$)	1885	1857	28	2	29	28	0.5	2
Age	≤ 86 years ($n=40$)	1758	1712	46	3	31	30	1.1	3
	≥ 87 years ($n=41$)	1620	1561	60	5	30	29	1.3	5
Length of stay	≤ 572 days ($n=40$)	1715	1687	28	3	31	30	0.7	3
	≥ 573 days ($n=41$)	1663	1586b	77	5	30	29b	1.6	5
Diagnosis	Dementia ($n=27$)	1831	1778	53	4	31	30	1.2	4
	Stroke ($n=21$)	1592	1544	48	3	28	27	1.0	3
	Other ($n=33$)	1633	1577	56	5	31	30	1.2	5
BMI	≤20.9 ($n=40$)	1663	1559b	104*	8*	35	32b	2.3*	8*
	≥21.0 ($n=41$)	1713	1710	3	0	26	26	0.1	0
Weight index	<80% ($n=40$)	1650	1550b	99	8*	35	32b	2.2*	8*
	≥ 80% ($n=41$)	1727	1719	8	0	26	26	0.1	0
Diets	Regular diets ($n=59$)	1695	1658	37	3	31	30	0.9	3
	Pureed foods ($n=22$)	1670	1574a	96	6	31	29a	1.8	6
Dietary supplements	Yes ($n=11$)	1707	1629	78	6	37	34	2.0	6
	No ($n=70$)	1686	1637a	49	4	30	29a	1.0	4
Katz ADL-index	A–E ($n=26$)	1682	1672	10	2	30	30	0.3	2
	F–G ($n=55$)	1692	1618a	73	5	31	29	1.6	5
PEM	Yes ($n=23$)	1635	1514a	121	9	36	33a	2.8	9
	No ($n=58$)	1710	1684	26	2	28	28	0.5	2
Ward	No 1 ($n=17$)	1877	1695b	182*	12*	36	32b	3.9*	12*
	No 2 ($n=18$)	1809	1824	−15	−1	32	33	−0.3	−1
	No 3 ($n=13$)	1516	1475	41	3	28	27	0.9	3
	No 4 ($n=23$)	1603	1617	−14	0	27	27	−0.1	0
	No 5 ($n=10$)	1572	1448a	124	9	28	26a	2.5	9

compared to period 2 by tertiles shows that 70% of the patients were classified correctly and only 2% were grossly misclassified by more than one tertile (Table 4) and Kendall's τ value was 0.67.

Corresponding analyses of fluid intake between periods showed no significant differences in relation to the above mentioned factors except for nursing home wards. The mean daily fluid intakes per kg body weight (BW) were 23 mL during period 1 and 22 mL during period 2 corresponding to a 1.1 mL difference/kg BW between the periods. Similar daily mean fluid intake were noted for men and women

Table 4 Cross-classification of energy intake (mean kcal/day) and water intake from food and beverages (mean gram/day) by tertiles during period 1 and 2 ($n = 81$)

		Energy intake (kcal) period 2			
		1034–1498	1499–1784	1785–2270	Total
Energy intake (kcal) period 1	1027–1502	21 (78%)	5 (18%)	1 (4%)	27
	1503–1882	5 (18%)	18 (67%)	4 (15%)	27
	1883–2344	1 (4%)	4 (15%)	22 (81%)	27
	Total	27	27	27	81
		Water intake (gram) period 2			
		1042–1605	1606–1833	1834–2520	Total
Water intake (g) period 1	1176–1619	21 (78%)	5 (81%)	1 (4%)	27
	1620–1928	5 (18%)	16 (59%)	6 (22%)	27
	1929–2632	1 (4%)	6 (22%)	20 (74%)	27
	Total	27	27	27	81

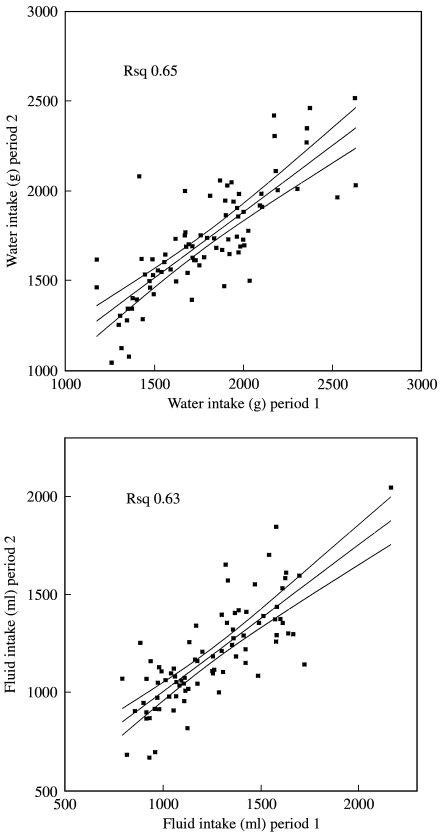

Fig. 1 Mean daily intake and distribution of water intake (g) from food and beverages and the corresponding fluid intake (mL) of patients ($n = 81$) in periods 1 and 2.

ranging from 1179 to 1263 mL between the periods. Cross-classification of fluid intake during period 1 compared to period 2 by tertiles shows that 65% of the patients were classified correctly and none was grossly misclassified by more than one tertile and Kendall's τ-value was 0.68.

Discussion

Numerous studies have used dietary records to validate 24-hour recalls, diet history and food frequency charts. A satisfactory method of estimating dietary intake must be repeatable, but few studies have been published on the reproducibility of food records and of those studies, most have been done with weight records and self-estimated food records for free-living younger people. Edington et al. (24) found a correlation value of 0.86 in energy intake when studying the repeatability of a 7-day estimated record in free-living adults. Jørgensen et al. (25) also found a good reproducibility of a 7-day estimated food record and Toeller et al. (26) of a 3-day estimated record. We have not been able to find any reproducibility studies with estimated dietary records in clinical settings where the ward staff has done the dietary assessing and recording.

In order to be able to test the reproducibility of a dietary record routine, the subject's dietary intake should be stable over time and the circumstances during the two measuring periods should be the same (11). However, even in the stable situation of a nursing home ward where all meals are supplied by the same hospital kitchen, is unlikely that patients eat and drink exactly the same amount during the two seven day periods. Thus some of the differences noted may reflect differences in intake.

The time gap between periods 1 and 2 was a deliberate attempt to eliminate bias introduced by learning effects among the recording personal. A gap of 4 to 8 weeks has been recommended between recording periods (38). In similar reproducibility studies the time gap has been between 3 and 8 weeks (24–26). It is possible that the

Table 5 Data for period 1 (*P*1) and 2 (*P*2) are given for mean daily water intake (WI), water intake per kg of body weight (WI/BW) and absolute differences (ΔW) and relative differences (ΔW%). Significant differences *between periods* are given as letters: a = $P<0.05$, b = $P<0.01$ and differences *within items* as: * = $P<0.05$, ** = $P<0.01$

		WI (g/day)		ΔW (g)	ΔW% (%)	WI/BW (g/kg)		ΔW/BW (g/kg BW)	ΔW%/BW (%)
		*P*1	*P*2	*P*1– *P*2	*P*1/*P*2	*P*1	*P*2	*P*1–*P*2	*P*1/*P*2
All	($n=81$)	1781	1722b	59	4	32	31b	1.2	4
Gender	Women ($n=56$)	1702	1631b	71	5	33	32b	1.5	5
	Men ($n=25$)	1958	1925	33	2	30	30	0.6	2
Age	≤ 86 years ($n=40$)	1860	1801	59	4	33	32	1.3	4
	≥ 87 years ($n=41$)	1705	1645a	60	4	32	31a	1.2	4
Length of stay	≤ 572 days ($n=40$)	1806	1761	45	3	33	32	0.9	3
	≥ 573 days ($n=41$)	1757	1684a	73	5	32	30a	1.5	5
Diagnosis	Dementia ($n=27$)	1864	1800	64	4	32	31	1.3	4
	Stroke ($n=21$)	1696	1677	19	2	30	30	0.5	2
	Other ($n=33$)	1767	1686a	81	5	34	32a	1.6	5
BMI	≤ 20.9 ($n=40$)	1780	1682a	98	7	37	35a	2.2	7
	≥ 21.0 ($n=41$)	1782	1761	21	1	28	27	0.3	1
Weight index	< 80% ($n=40$)	1764	1664a	100	7	37	35b	2.3*	7
	≥ 80% ($n=41$)	1797	1778	20	1	28	27	0.2	1
Diets	Regular diets ($n=59$)	1757	1696a	53	3	32	30b	1.0	3
	Pureed foods ($n=22$)	1846	1793	62	4	34	33	1.3	4
Dietary supplements	Yes ($n=11$)	1695	1573	123	9	36	33	3.0	9
	No ($n=70$)	1795	1745a	49	3	32	31a	1.0	3
Katz ADL-index	A–E ($n=26$)	1763	1742	21	2	31	31	0.4	2
	F–G ($n=55$)	1790	1712a	78	5	33	31a	1.6	5
PEM	Yes ($n=23$)	1748	1623b	125	9	38	35b	2.9*	9
	No ($n=58$)	1794	1761	33	2	30	29	0.6	2
Ward	No 1 ($n=17$)	1936	1721b	215*	13*	38	33b	4.3**	13*
	No 2 ($n=18$)	1825	1794	32	2	33	32	0.8	2
	No 3 ($n=13$)	1696	1704	−8	0	32	32	−0.1	0
	No 4 ($n=23$)	1704	1718	−14	−1	29	29	−0.2	−1
	No 5 ($n=10$)	1725	1626	100	7	31	30	1.9	7

medical and physical condition of some patients may have changed over this interval, and such changes may be reflected in their dietary intake.

The menus offered by the hospital kitchen cycle through a 5-week rotation and several serving alternatives were available for every meal, so it was not possible to ensure that all aspects of the situation were identical for both measurement periods. This was particularly the case because of our concern that the ward staff should not change any routines during the study, other than filling in the dietary records. This concern reflects our desire to conduct this study in a real-world clinical setting, given that the dietary record routine is intended to be used clinically.

Given the constraints outlined above, the mean difference of 4% in energy and water intake and 6% in fluid intake between the two periods indicates the stability of this method.

The patients who dropped out of this study generally did so during the start-up period before dietary recording began. The main reasons for dropping out were death and illness. The fact that some patients dropped out may have had some effect on the mean dietary intake, for some of the patients who died probably had a lower intake prior to recording due to terminal decline. Thus the results obtained from repeated assessment of a group may be a little higher in our study than in other cross-sectional studies of nursing home patients with only one assessment period. In a previous study on nursing home patients (10) the mean energy intake was 1280 kcal for women compared to 1569 in this study and 1557 kcal for men compared to 1871 kcal in this study.

The lower correlation coefficient values obtained for men in general may to some extent be explained by the narrower distribution of men compared to women in this study and by the larger portion sizes eaten by the men, as indicated by the higher energy intake. The lower correlation coefficients for vitamin A and iron in men may be due to sporadic intake of liver, rich in vitamin A, during one of the periods.

The mean daily fluid intakes in men and women were about the same, despite a 14 kg higher mean body weight in the men. The results indicate that the individual's need for fluid was not being met. Studies have showed that geriatric patients do not get the necessary fluid intake (39) and that dehydration in the institutionalized elderly can be an indicator of inadequate care (40). Blower (41) has shown that patients who were thirsty but unable to drink independently often waited to ask for help because they did not want to disturb the ward staff. Adams (42) showed that most of a geriatric patient's fluid intake takes place during the daytime and that the patients often drink the entire amount that is offered to them. We have not been able to find any published studies on the reproducibility of water and fluid intake in geriatric patients.

Estimated dietary recording by ward staff in clinical settings and using the quartile method has been shown to correlate very well with the weight of food consumed (43). Since the ward staff served almost all food and beverages on the wards and since the same calibrated utensils were used when serving the food, we believe that the precision in this study is acceptable. A weighed diet record is not a better option in a clinical setting where the ward staff is doing the recording for several patients at one time. Even though a weighed dietary record may more accurately assess the amount of food eaten and the food waste, the method takes longer to carry out and may entail a higher risk of changed dietary intake due to the recording itself. We believe that an estimated dietary record is ultimately superior as a dietary recording routine intended to be used by the ward staff in a clinical setting.

The accuracy of the method was not influenced by diagnosis, type of diet or uses of supplements, function as defined by Katz ADL index, age, gender or length of stay on the ward. This is especially important if the method is being used to identify persons at risk of developing malnutrition. A difference between periods was noted for patients with low body weight as indicated by weight index and BMI. This group of patients probably has the most frail elderly, and consequently a more fluctuating dietary intake. All but 2 of the 23 patients classified as having PEM were in the group with a BMI below the median. It is, of course, also possible that some of the patients with suspected energy malnutrition have clinically undetected conditions. Significant differences were found between the different nursing home wards, which may indicate that the method is affected by the wards staff's interest in performing the study and the different routines on the wards, such as how the nursing care was organised and the routines during mealtimes.

It has previously been suggested that a 7-day dietary recording period is long enough to correctly rank and categorize by tertiles 80% of individuals' intake of energy, carbohydrates and protein with 95% confidence (17). The limitations are the result of intra- and intersubject variation in dietary intake. In our study 75% of the patients were classified correctly in terms of energy intake and only a few patients were grossly misclassified by more than one tertile.

The values of the nutrient intake do not reflect what the intake of this group of frail elderly ought to be. The calculation of the nutrient intake was based on the recipes. We have not taken into account nutrient losses during the food preparation and transportation. Such losses would most affect vitamin C and to some extent to thiamine, riboflavin and vitamin B6. The true intake of these nutrients is probably lower than we have reported in this study (44).

Sidenvall (45) found that the meal procedures at institutions for elderly people were governed by the ward staff's routines rather than by individual patient's needs. Thus, the mealtimes were more task-oriented than patient-oriented and failed to meet the patients' nutritional needs. Studies have also shown a lack of knowledge of how to assess patients' nutritional needs, as well as inadequate action to meet these needs (46, 47). However there are ways to improve patients' nutritional care. Olsson et al. (48) showed that an education and training program for nurses improved the nutritional assessments and interventions. Elmståhl et al. (49) found that a changed meal environment could increase the patients' energy intake. Ödlund Olin et al. (43) showed that energy-enriched meals can improve patients' energy intake and Larsson et al. (8) found that dietary supplements can both increase energy intake and reduce mortality. An accurate method of dietary assessment is crucial to assessing risk groups as well as the effects of changes in intervention studies. It is also crucial that ward staff should be given an appropriate training in assessing dietary intake. Pokrywka et al. (50) have suggested that a feasible solution would be to develop a standardized training program that could be offered to the ward staff at a regularly scheduled intervals to accommodate the large turnover in the ward staff.

We have compared our study group to the official Swedish statistics (51) on people living in nursing homes and in special needs housing for elderly and to a national survey of 407 nursing homes in Sweden (52). Our study group had the same distribution as regards to sex and almost the same distribution as regards to diagnosis, Katz ADL index and age. Some differences were noted with longer length of stay in our group and more patients over the age of 90, but otherwise the distributions were similar.

Conclusions

The 7-day dietary record routine based on standardized portion sizes and household measuring seems to have a good reproducibility in assessing the intake of energy and fluids in geriatric patients. The measurement method is intended to be used by the ward staff in a clinical setting to assess and evaluate the patients' energy and fluid intake. We hope that such an evaluated clinical method can be one way to increase the ward staffs' knowledge of individual patients' nutritional needs and to increase the energy and nutrient intake of chronically ill and frail hospitalized elderly patients.

Acknowledgements

This study was supported by grants from: Lund University, the Municipality of Malmö, Nutricia Nordica AB, Påhlsson's Foundation, the Swedish Foundation for Health Care Sciences and Allergy Research (grant no V97 234), the Swedish Society of Nursing and the Swedish Nutrition Foundation.

Appendix 1

Food and Fluid Chart

Nutrition Chart 2000 Region Skåne, Sweden

TRANSLATED FROM SWEDISH

Date: ....

Type of diet: ....

Portion size: ....

Name:

ID#:

Ward:

Food intake

Time	***Breakfast***	Served amount	Eaten amount	kcal
	Porridge, kind: dl			
	Eggs #			
	Sandwich #			
	Sugar, granulated tbs			
	Sugar, lumps #			
	Jam/Fruitpurée tbs			
	Lunch/Dinner Main dish portion size	1/1 3/4 1/2 1/4	1/1 3/4 1/2 1/4 0	
	Porridge, kind: dl			
	Hot soup dl			
	Sandwich #			
	Dessert, kind:			
	Supper/Evening meal Main dish portion size	1/1 3/4 1/2 1/4	1/1 3/4 1/2 1/4 0	
	Porridge, kind: dl			
	Hot soup dl			
	Sandwich #			
	Dessert, kind:			
	Snack between meals			
		Sum food chart (kcal)		

Fluid intake chart

Time	Drinks	Served amount mL	Eaten amount mL	kcal
	↑ *Enteral Tube Feeding Formulas - begin at the bottom*			
Sum enteral tube feeding formulas (mL/kcal)				
Sum other enteral tube feeding fluid (mL/kcal)				
	Sum fluid chart (mL/kcal)			
	Total			

Fluid losses

Time	Urine mL	Vomit mL	Diarrhoea mL
Sum			
Time	mL	mL	mL
Sum			

Appendix 2

Energy Contents Guide
TRANSLATED FROM SWEDISH

Sandwiches, bread and butter	*Amount*	*kcal*
Sandwich (open), bread and margarine with cheese/ham	1 ea	150
Crispbread and margarine with cheese/ham	1 ea	110
Crispbread	1 pce	40
Slice of bread	1 pce	60
Spreading fats, soft low fat margarine, 40% fat	1 portion/l0 g	30
Spreading fats, soft regular margarine, 80% fat	1 portion/l0 g	70
Beef meat	1 slice/10 g	20
Cheese	1 slice/15 g	40
Ham, boiled/smoked	1 slice/20 g	20
Liver paste, soft cheese, soft whey-cheese	1 portion /15 g	40
Sausage (mettwurst), boiled/smoked (polony)	1 slice/10 g	40
Porridge, Eggs, Sugar and Jam		
Corn Flakes	1 dl	50
Eggs	1ea	80
Herring, pickled	1 small slice/l0 g	20
Jam, Apple-sauce, Honey	1 tbs	60
Jam unsweetned	1 msk	20
Linseed, dried	1 tbs/10 g	40
Müsli, plain	1 dl	140
Porridge, cooked on water, like oatmeal porridge	1 dl	50
Porridge, cooked on milk, like semolina pudding	1 dl	100
Porridge, childrens porridge (powdered-based)	1 dl	100
Prunes	1 pce/5 g	10
Sugar, granulated	1 tbs	60
Sugar, lump	1 lump/3 g	10
Wheat bran	1 tbs/5 g	10
Lunch/Dinner/Supper		440
Regular main hot meal including meat/fish, potatoes/rice, vegetables, sauce/jam	1/1 port	330
	3/4 port	220
Please contact the dietian or the kitchen about the energy contents of modified diets.	1/2 port 1/4 port	110
Baby Foods (Savoury dishes)	100 g/l dl	90
Fresh fruit		
Apple, Orange, Peache, Pear	1 ea/150 g	80
Apricot, Clementine, Kiwi fruit	1 ea/70 g	30
Banana	1 ea/100 g	100
Blueberries, Cherries, Currants, Gooseberries	1 dl/60 g	30
Plums	1 ea/35 g	20
Grapes	1 dl/70 g	50
Raspberries, Strawberries	1 ea/60 g	30

Desserts	*Amount*	*kcal*
Apple cake with sauce, Swedish Cheesecake with jam, Pancakes 2 pce with jam, Waffle 1 pce with jam	1 portion/2 dl	250
Fruitpurée (tinned baby food)	100 g/1 dl	80
Ice cream, low fat	1 tub/65 g	70
Ice cream, regular	1 tub/65 g	150
Stewed fruit,Tinned fruit, Fruit salad	1 portion/2 dl	100
Cakes, Cookies, Pastries and Sweets		
Biscuits, Gingerbread biscuit	1 ea/5 g	30
Cakes, Sponge cake, Swiss roll	1 slice/30 g	120
Candy, Caramels, Sweets, Toffees	1 ea/5 g	20
Cookies, Shortbread	l ea/l0 g	50
Confectionary bars, Danish pastries, Éclair	1 st/ca 50 g	200
Milk chocolate, Wafers filled coverd with milk chocolate	100 g	550
Pastries, Gateau, Whipped cream layer cake	1 slice/l10 g	320
Rusks (*1 rusk with spreading fats = 50 kcal*)	l ea/10 g	40
Sweet wheat bread plain (coffe-cake)	1 slice/25 g	80
Sweet wheat bread buns (coffe-cake)	1 st/ca 50 g	150
Sweet wheat bread filled (coffe-cake)	1 slice/30 g	100
Wafer plain (*Dubble wafer with spreading fats = 30 kcal*)	1 st/ca 2 g	10
Dairy products		
Fermented milk, skim, very low fat 0.5%	100 mL	40
Fermented milk, fat 3%	100 mL	60
Fruit yoghurt, fat 2.5%	100 mL	90
Fruit yoghurt, skim, very low fat 0.5%	100 mL	70
Cream coffe fat 12%, Sour creame (*1 tbs = 20 kcal*)	100 mL	130
Fermented milk. low fat 1.5%	100 mL	50
Milk, skim, very low fat 0.5%	100 mL	40
Milk, fat 3%	100 mL	60
Whipping cream, not whipped (*whipped: 1 tbs = 30 kcal*)	1 tbs	60
Beverages and Soups		
Beef tea	100 mL	10
Beer (light/small bear)	100 mL	30
Coffee, tea (*don't forget sugar, cream/milk*)	100 mL	0
Dessert soup, Fruit-syrup soup, Rose hip soup	100 mL	50
Fruit fool/jelly	100 mL	90
Fruit juice	100 mL	50
Gruel	100 mL	70
Milk chocolate drink	100 mL	80
Soft drinks, Carbonated beverages (*not light products*)	100 mL	40
Soft drinks unsweetned	100 mL	20
Soup, dessert soup, enriched (liquid diet)	100 mL	100
Soup, dinner soup, enriched (liquid diet)	100 mL	120
Soup, dinner soup (*not pea soup with pork*)	100 mL	60
Wine	100 mL	70
Dessert wine, Spirits	1 cl (10 mL)	20

Dietary Supplements, Industrial made Oral Drinks:
—local brand names

Dietary Enrichment and Supplement Powders and Liquid Thickening Powders:
—local brand names

Enteral Tube Feeding Formulas and Parenteral Nutrition Solutions:
—listed seperatly

Standard Measures*	*Amount*
Coffee-cup, large	150 mL
Coffee-cup, small	125 mL
Disposable glass/cup, small	75 mL
Disposable glass/cup, large	150 mL
Drinking-glass (tumbler), normal	175 mL
Drinking-glass (tumbler), small	150 mL
Feeding cup	225 mL
Soup plate	250 mL
Tablespoon (tbs)	15 mL
Teacup, large	275 mL
Teaspoon (tsp)	5 mL

(*100 mL = 1 dl = 0.1 liter*)

**NOTE: Standard measures commonly used in Swedish hospitals. The measures can vary depending on the kind of service set used. The amounts indicated above refer to cups and glasses filled up to 1 cm from the rim.*

NOTE: The energy numbers (calorie content of serving) listed above are approximated values to make the adding easier.

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Submission date: 21 June 2000 *Accepted:* 6 July 2001

III

European Journal of Clinical Nutrition (2000) 54, 789–796

www.nature.com/ejcn

Validation of a dietary record routine in geriatric patients using doubly labelled water

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Objective: To validate a 7-day estimated dietary record routine with standardized portion sizes and household measuring in a clinical setting with the doubly labelled water (DLW) method as the reference method.
Design: Energy expenditure was measured with deuterium (^{2}H) and oxygen-18 (^{18}O), and water loss was estimated by ^{2}H dilution as part of the DLW measurements. Energy and water intake was measured with a 7 day dietary record.
Setting: Five nursing home wards in Sweden.
Subjects: Thirty-one geriatric patients with a mean age of 86 y. Inclusion criteria were stable body weight, defined as a maximum change of 4% during the last 4 months of 2% during the last 2 months and without any acute illness.
Results: The mean daily energy intake was 7.2 MJ (1727 kcal) and the mean daily energy expenditure was 6.7 MJ (1595 kcal). The mean daily water intake was 1787 ml and mean daily water loss assessed by labelled water was 1774 ml. Using the dietary record routine, the staff overestimated the patients' energy intake by 8% and water intake from food and beverages by 1% compared to DLW.
Conclusion: The 7 day dietary record routine based on standardized portion sizes and household measuring seems to be a valid method for assessing the intake of energy and fluids by geriatric patients.
Descriptors: malnutrition; aged; validity; diet records; doubly labelled water; body water
European Journal of Clinical Nutrition (2000) **54,** 789–796

Introduction

Malnutrition in nursing home residents is an important clinical and public health problem. One important factor contributing to its prevalence appears to be the failure of health care professionals to recognize its signs and identify patients with malnutrition or at risk of becoming malnourished (McWhirter & Pennington, 1994; Mowé & Bøhmer, 1991; Roubenoff *et al*, 1987). Several studies have shown that patients with malnutrition are not diagnosed correctly (McWhirter & Pennington, 1994; Mowé & Bøhmer, 1991; Roubenoff *et al*, 1987) and that the documentation in medical and nursing records in insufficient (Abbasi & Rudman 1993; Mowé & Bøhmer, 1991; Ulander *et al*, 1991). A high rate of malnutrition in elderly patients has been noted in various clinical settings by many investigators during the last few decades (Clarke *et al*, 1998; Tierney, 1996) and is accompanied by a high mortality rate (Cederholm, 1994; Elmståhl *et al*, 1997; Larsson *et al*, 1990). In a recent study of a novel dietary record routine for nursing home patients (Elmståhl *et al*, 1997), investigators found that the energy intake was less than the calculated energy expenditure for 84% of the patients and 30% of the patients had an intake below estimated basal metabolic rate.

Different methods of assessing dietary intake are available for use in identifying malnutrition and patients at risk of becoming malnourished (Cameron & Staveren, 1988; Gibson, 1990). Retrospective methods include dietary history, food frequency questionnaire and 24 h recall, whereas prospective methods include the use of dietary records and duplicate meals. The staff-administered dietary record is the method of choice for monitoring nutritional status in geriatric patients (Cameron & Staveren, 1988), because the findings are not influenced by the various kinds of illnesses and levels of cognitive impairment that are common in this population. Food and fluid intake must be recorded for several days before the patients' intakes can be classified, due to intra- and interpersonal variations (Bingham, 1991; Nelson *et al*, 1989). The doubly labelled water (DLW) method can be used to assess energy expenditure and is thereby an independent method to assess the validity of dietary records in assessing energy intake (Prentice, 1990; Speakman, 1997). However, to our knowledge, no study has been performed on elderly hospitalized patients using a 7-day dietary record routine and DLW concurrently. It is important to validate estimated energy intake in this group of patients if the comparison of energy intakes with recommended dietary amounts for hospitalized elderly are to be meaningful.

The dietary record routine, which is based on standardized portion sizes and household measurement, has been adapted for use by the ward staff in a real world clinical

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setting. Such records have been used clinically during the past few years by various public health systems to estimate patients' food intake. So far, to our knowledge, the validity of using such has not been tested.

Methods of identifying fluid imbalance in hospitalized geriatric patients may also be lacking. This population is at risk for dehydration because the elderly have a diminished sensation of thirst and are less able to regulate their fluid balance (Crowe *et al*, 1987; Phillips *et al*, 1991). If left untreated, dehydration can result in death in many cases (Mahowald & Himmelstein, 1981; Warren *et al*, 1994). Dehydration is poorly defined and its clinical signs can be vague, especially in the elderly (Chernoff, 1994; Weinberg & Minaker, 1995). Water balance studies, particularly those that focus on water intake in weight-stable geriatric patients, may provide information that can help us to better identify dehydration in this susceptible population and diminish associated mortality rates.

The purpose of this study was to validate a 7-day estimated dietary record routine with standardized portion sizes and household measuring in a real world clinical setting with the doubly labelled water method as a reference. The dietary record routine has been used in a previous study (Elmståhl *et al*, 1997) and it is intended to be used in further studies as a screening instrument to detect geriatric patients at risk of developing malnutrition.

Methods

Population

The study population was recruited from five Swedish nursing home wards. Inclusion criteria were nursing home residence, ability to ingest food and fluid orally, and stable body weight, defined as a maximum change of 4% during the last 4 months or 2% during the last 2 months. Exclusion criteria were parenteral or enteral nutrition, acute illness, inflammatory conditions, anemia, hypo- or hyperthyroidism, terminal conditions, and protein-energy malnutrition (PEM) as defined by biochemical and anthropometric criteria (Table 1). Blood samples were taken to measure albumin, prealbumin, hemoglobin, triiodothyronine, thyroid-stimulating zhormone, prothrombin, orosomucoid and other blood factors.

Dietary intake

Before the study period started, the ward staff attended a 2 h training session on taking dietary records, conducted by the first author and an experienced clinical dietician. The training consisted of oral and written information on the dietary record routine and practical training in assessing portion sizes using both real dishes and photographs of different dishes. During the study period, the ward staffs were provided written information on the recommended portion sizes and photographs of the different portion sizes, but received no direct assistance from the investigators other than having their questions answered. The record-keeping staff, consisting of registered nurses, practical nurses and nurse assistants, was instructed not to alter any routines during the study.

Dietary intake was recorded for 7 consecutive days by the ward staff and individual charts were obtained daily. The record form is a newly developed estimated dietary record form for use in clinical settings and is designed to be as self-explanatory as possible. It is in A4 size and has two pages. The front page is for individual dietary recording over a 24 h period and the back page gives information about the energy content of some 100 food items that are common in a hospital setting.

Table 1 Criteria for protein energy malnutrition and cut-off levels

Variables	*Normal value*	*Low value*
Weight index[a] (%)	80	80
Triceps skinfold (mm)		
women 70–79 y	13	13
women 79 y	10	10
men 70–79 y	6	6
men 79 y	6	6
Arm muscle circumference (cm)		
women 70–79 y	19	19
women 79 y	18	18
men 70–79 y	22	22
men 79 y	21	21
Serum albumin (g l)	36	36
Serum prealbumin (g l)		
women	0.18	0.18
men	0.20	0.20

Cut-off points according to Swedish norms (Björkelund *et al*, 1997; Symreng, 1983).
A low value for three or more variables is an indicator of protein energy malnutrition (PEM).
[a]Weight index according to Swedish height and weight tables.

Standardized portion sizes using the quartile method (0, 1 4, 2 4, 3 4, 1 1) were used for lunch and dinner; breakfast, snacks and beverages were assessed separately using household measuring devices. Energy and water intake was calculated using a nutrient computer software program (AIVO Kostplan 1.25, Sweden 1997 and Food Composition Table from Swedish PC-kost, December 1997). Fluid intake was calculated from all consumed beverages. Water intake was calculated, using food composition tables, from the combined intake from fluids and from food items. The food was prepared by the hospital kitchen staff and was served by the ward staff. The recipes from the hospital kitchen were used to calculate the energy content of each meal. Swedish norms for the mean weight and or volume of different food items and portion sizes were used for consumed snacks and beverages consumed (Gilback *et al*, 1988; Statens Livsmedelsverk, 1992). The utensils used on the wards were calibrated by volume. Metabolic water was calculated using the equation 1.07 g water g fat, 0.60 g water g carbohydrate, and 0.41 g water g protein (Fjeld *et al*, 1988). The dietary records were coded by the first author and then checked independently by an experienced clinical dietician in order to avoid coding errors.

Energy expenditure

The energy expenditure of each patient was measured using doubly labelled water (DLW) with the stable isotopes deuterium (^{2}H) and oxygen-18 (^{18}O) (Prentice, 1990; Speakman, 1997). The amount of isotope was calculated for each individual according to total body water, which was measured by bioimpedance (BIA-109, RJL, Michigan, USA). The isotopes were administered as a mixture of ^2H_2O and $H_2{}^{18}O$ with a calculated initial excess body water enrichment of 150 ppm for ^{2}H and 300 ppm for ^{18}O. Individual doses were stored in an airtight screw-cap glass container and at +4°C. The isotopes were given orally in water. The patients drank approximately 75–100 ml, then the sample bottle was rinsed with approximately 50 ml of tap water, which was also consumed.

Table 2 Mean energy intake (EI) *vs* DLW-estimated energy expenditure (EE) (s.d.)

	Women (n = 18)	*Men (n = 13)*	*All (n = 31)*
Energy intake			
kcal	1607 324	1892 204	1727 311
range	1124–2165	1496–2239	1124–2239
Energy expenditure			
kcal	1453 272	1791 317	1595 333
range	1009–2079	1255–2290	1090–2290
EI overestimation compared with EE (%)	+10.1	+5.6	+8.4
Spearman's rank correlation coefficients between EI and EE	0.78	0.80	0.81
Mean difference between EI and EE			
kcal	+154 213	+101 193	+132 203
range	−293– +470	−246– +551	−293– +551

The isotopes were given in the evening, just before the patients were going to bed. Before each dose was administered, investigators collected a background blood sample from the subject. The first blood sample was collected before breakfast after an overnight fast without any food or fluid intake. The mean equilibration interval, the time between isotope dosing and collection of the first blood sample, was 10.4 h (s.d.: 0.8 h; range: 8.5–13.4 h). The samples were taken by venipuncture using a vacuum system (Becton Dickinson Sterile Vacutainer systems). Within half an hour after the sample was taken, the serum was separated by centrifuge for 10 min, then transferred to an airtight screw-capped glass container and immediately frozen to −20°C. A total of nine samples were taken from each patient: one sample before the dose, and one sample in the morning and one in the evening of days 1, 8, 15 and 22 of the study.

Sampling from the participants in DLW studies is often done by urine, however has saliva and blood serum or plasma has also been used (Prentice, 1990; Speakman, 1997). Saliva has mostly been used in studies with small children. In a population of geriatric patients the prevalence of urine incontinence is usually high, in Swedish nursing homes about 60% of the patients suffer from incontinence (Hedvall *et al*, 1994). Thereby it is a great practical problem to get urine samples at specific time intervals as the study protocol states. In that context we chose to perform this study with blood samples, even though the invasive method of venipuncture could annoy the patients.

The samples were analysed by isotope ratio mass spectrometry (Aqua Sira, VG, UK). Administration and analyses of the samples followed the Maastricht protocol (Westerterp *et al*, 1995). In the calculation of energy expenditure and water loss, the individual changes in body weight during study has been taken into account.

Water loss

Water loss was estimated by ^{2}H dilution as part of the DLW measurements (Marken Lichtenbelt *et al*, 1994; Westerterp *et al*, 1995). The calculation of water loss has in detail been described before (Westerterp, 1999).

Ethics

Each patient and or a close relative gave an oral informed consent to the patient's participation in the study. The study was approved by the Local Ethical Committee at Lund University, Sweden.

Statistics

Statistical analyses was performed using *SPSS for Windows* (8th edn Chicago, SPSS Inc. 1997). Values are expressed as means and standard deviations (s.d.). In the sub-group analysis (Tables 3 and 5) the item weight index was set at 80%, in accordance with the criteria for PEM (Table 1). Non-parametric methods were used when analysing data as the samples were small and were not normally distributed (Altman, 1996). The relationship between energy intake and energy expenditure, as well as between water intake and water loss, was examined using the two-tailed Spearman's rank correlation coefficient. The cross-classification by tertiles was examined using the chi square test. The sub-group analysis (Table 3 and 5) was examined using the

Table 3 Energy intake (EI) and DLW-estimated energy expenditure (EE) and influence of body weight (BW) ($n = 31$). Difference between EI and EE (E) and relative difference (E%)

		EI (kcal)	*EI kg BW (kcal)*	*EE (kcal)*	*EE kg BW (kcal)*	*E (kcal)*	*E (%)*
Gender	Women ($n = 18$)	1607**	29	1453**	26	154	11
	Men ($n = 13$)	1892	27	1791	26	101	7
Age	86 y ($n = 11$)	1834	30	1659	27	175	13
	86 y ($n = 20$)	1667	27	1559	26	108	8
BMI	25 ($n = 21$)	1643*	29	1448**	26	195*	14*
	25 ($n = 10$)	1903	26	1903	26	0	1
Katz ADL-index	A–E ($n = 13$)	1710	29	1630	27	80	6
	F–G ($n = 18$)	1739	28	1570	25	169	12
Eating	Independent ($n = 26$)	1722	28	1622	26	99	7
	Total help ($n = 5$)	1754	31	1452	25	302	22
Weight index	80% ($n = 10$)	1627	32**	1418	28	209	14
	80% ($n = 21$)	1774	27	1679	25	95	7
Diagnoses	Dementia ($n = 11$)	1881	29*	1804	28*	77	16
	Stroke ($n = 7$)	1534	27	1304	23	230	18
	Other ($n = 13$)	1700	28	1574	26	126	8

* = P 0.05; ** = P 0.01.

Table 4 Cross-classification of energy intake (mean kcal day) and DLW-estimated energy expenditure by tertiles ($n=31$)

	Energy expenditure estimated by DLW (kcal)		
Energy intake (kcal)	*1009–1436*	*1437–1695*	*1696–2290*
1124–1631	8	2	0
1632–1907	2	6	3
1908–2239	0	3	7

Mann–Whitney test. The Kruskal–Wallis test was used for the item diagnosis. Results were considered statistically significant if *P*-values were less than 0.05.

Results

Of 102 patients, 37 matched the study criteria and agreed to participate. Data are not available for six of the 37: three patients terminated their participation in the study; in two patients it was impossible to get the required blood samples; and in one patient there was no enrichment of the DLW probably due to the dose not being properly consumed. Thus, the study group consisted of 31 patients (18 women and 13 men) with a mean age of 86 y (s.d.: 6 y; range: 65–96 y). The mean length of time spent on the wards was 709 days (s.d: 531 days; range: 73–2346 days). The most common diagnoses were dementia ($n=11$), stroke ($n=7$), neurological disorders ($n=3$), and orthopedic disorders ($n=3$). According to Katz ADL-index (Brorsson & Hulter Åsberg, 1984; Katz *et al*, 1963), the participants were highly dependent on others in activities of daily life (ADL), as indicated by a score of F or G for 18 of the 31 patients, and five patients were dependent in all activities. Only four patients were highly independent, as indicated by scores of A or B. The remaining patients had Katz ADL-index scores of C or E. The mean body weight was 55.8 kg (s.d.: 9.1 kg; range: 45.0–74.8 kg) for women and 69.8 kg (s.d.: 8.1 kg; range: 56.0–85.5 kg) for men. Mean body mass index (BMI) was 22.6 (s.d.: 3.6; range: 16.3–28.2) for women and 24.2 (s.d.: 3.4; range; 18.9–29.6) for men. Twenty-six of the 31 patients had a BMI between 20 and 30, and none had a BMI 30. The mean change in body weight during the study was −0.5 kg (s.d.: 1.9 kg; s.e.m: 0.4 kg; $n=29$). Body weights for two patients were missing at the end of the study, as one patient died and another was relocated after the DLW sampling was finished but before a new body weight value could be measured.

The mean ^{2}H and ^{18}O dilution space ratio was 1.029 (s.d.: 0.007: range: 1.007–1.039), which indicates a relatively low variance in the method. We found no significant age or gender differences.

Energy

The mean energy intake was 7.2 MJ day (s.d. 1.3): 6.7 MJ day (s.d. 1.4) for women and 7.9 MJ day (s.d. 0.9) for men. The mean energy expenditure was 6.7 MJ day (s.d. 1.4): 6.1 MJ day (s.d. 1.1) for women and 7.5 MJ day (s.d. 1.3) for men. Using the 7-day dietary record routine, the staff overestimated the mean energy intake by 8.4% when compared to energy expenditure (Table 2). The Spearman's rank correlation coefficients between energy intake and energy expenditure was 0.81 (P 0.001): 0.78 (P 0.001) for women and 0.80 ($P=0.001$) for men.

The difference between energy intake and energy intake and energy expenditure (E = EI−EE) and the relative difference (E%) were examined in relation to gender, age, body weight, ADL independence, eating ability and diagnoses. No statistically significant differences between E and E% were noted for age, ADL independence *vs* dependence, or independence *vs* total dependence during

Table 5 Mean water intake (ml day) *vs* labeled water estimated water loss (ml day) (s.d.)

	Women ($n=18$)	*Men ($n=13$)*	*All ($n=31$)*
Water intake[a] (ml)	1697 211	1911 285	1787 263
range	1123–2052	1532–2464	1123–2464
by body weight (ml kg)	31 5	28 4	29 5
range	24–40	22–36	22–40
Fluid intake (ml)	1161 242	1206 266	1180 249
range	682–1599	869–1848	682–1848
by body weight (ml kg)	21 5	17 3	20 5
range	14–31	12–23	12–31
Food water[b] (ml)	536 161	705 91	607 159
range	138–785	543–889	138–889
Total water intake[c] (ml)	1908 236	2159 302	2014 290
range	1269–2283	1756–2729	1269–2729
by body weight (ml kg)	35 6	31 4	33 5
range	27–45	25–40	25–45
Metabolic water (ml)	212 45	248 25	227 41
range	146–282	199–289	146–289
Water loss estimated by DLW (ml)	1673 286	1914 432	1774 368
range	1070–2150	1260–2580	1070–2580
by bodyweight (ml kg)	30 5	27 5	29 5
range	20–38	20–34	20–38
Mean difference between total water intake and water loss (ml)	235 166	246 293	240 224
range	−104– +524	−214– +689	−214– +689

[a]Water intake includes water from food and beverages, but not metabolic water.
[b]Food water is here defined as water intake minus fluid intake.
[c]Total water intake includes water from food and beverages and metabolic water.

mealtime corresponding to a score of G on the Katz ADL index (Brorsson & Hulter Åsberg, 1984; Katz *et al*, 1963). Statistically significant differences were found between gender groups, body-weight groups, and diagnoses (Table 3). Cross-classification of energy intake compared to energy expenditure by tertiles showed that 68% of the patients were classified correctly and none was grossly misclassified by more than one tertile (Table 4), and Kendall's tau-value was 0.69.

Water

Mean water intake was 1787 ml day (s.d. 263): 1697 ml day (s.d. 211) for women and 1911 ml day (s.d. 285) for men. Labelled water estimated mean water loss was 1774 ml day (s.d. 368): 1673 ml day (s.d. 286) for women and 1914 ml day (s.d. 285) for men. Using the 7 day dietary record routine, the staff overestimated mean water intake from food and beverages by 0.7% when compared to water loss (Table 5). The Spearman's rank correlation coefficients for the difference between water intake and water loss was 0.82 (P 0.001): 0.77 (P 0.001) for women and 0.79 (P 0.01) for men.

The difference between water intake and water loss (W = WI−WL) and the relative difference (W%) were examined in relation to gender, age, body weight, ADL independence, eating ability and diagnoses. No statistically significant differences in W and W% were noted between gender groups, high and low age, different diagnoses, and independence *vs* total dependence during mealtime corresponding to level G in Katz ADL index (Brorsson & Hulter Åsberg, 1984; Katz *et al*, 1963). Statistically significant differences were found between body-weight groups and ADL-independence dependence groups (Table 6). Cross-classification of water intake compared to water loss by tertiles showed that 61% of the patients were classified correctly and none was grossly misclassified by more than one tertile (Table 7) and Kendall's tau-value was 0.63. No differences in the cross-classification were found when metabolic water oxidation was taken into account. No evidence of dehydration, defined by hemoglobin of 113−153 g l for women and 122−166 g l for men, was found.

Discussion

Although studies have been published on the validity of healthy elderly people's energy intake (Rothenberg, 1997), to our knowledge, this is the first study to use DLW as a means of validating energy and fluid intake information recorded in a dietary record routine among institutionalized geriatric patients. To ensure the reliability of this comparison, we had to overcome the fact that various types of medical conditions can change metabolism and absorption or cause excessive nutritional losses. We also had to consider the fact that dietary intake can be impaired by psychiatric disorders and functional incapacity caused by movement disorders or swallowing problems (Elmståhl *et al*, 1987; Morely, 1997). Hospitalization, the patient's mealtime situation, the numbers of persons from the ward staff present during mealtimes, eating facilities and ambience can affect food intake (Elmståhl *et al*, 1987). Sidenvall (1995) showed that the skills and values of staff highly affected mealtimes and the quality of individual patient care.

For these reasons, we selected geriatric patients who had no diseases or conditions that could affect their energy metabolism, patients who had a stable body weight, normal body temperature, and no evidence of acute illness. Thus, our study population was generally healthier than many geriatric nursing home patients and thereby probably had a higher mean energy intake at a group level compared with all nursing home patients.

In a number of studies, higher energy intake values have been reported by investigators using dietary history method compared to 7 day dietary record (Block, 1982). Most of these diet history studies demonstrated reliability but not validity due to the lack of an existing 'gold standard'. Furthermore, the energy intake indicated by dietary records tends to be lower than the energy expenditure determined in studies based on DLW or calculated energy expenditure (Black *et al*, 1995). However, in a study by Prentice *et al* (1989), the energy intake measured with a 7 day weighted dietary records overestimated the energy expenditure measured with DLW in 14 geriatric patients. Similar findings were noted for children when their intake was reported by their parents (Livingstone *et al*, 1992). We also noted an overestimation of energy intake using the dietary record

Table 6 Total water intake[a] (WI) and labeled water estimated water loss (WL) and influence of body weight (BW) ($n = 31$). Difference between WI and WI (W) and relative difference (W%)

		WI (ml)	*WI kg BW (ml)*	*WL (ml)*	*WL kg BW (ml)*	*W (ml)*	*W (%)*
Gender	Women ($n = 18$)	1908*	35	1673	30	115	15
	Men ($n = 13$)	2159	31	1914	27	116	16
Age	86 y ($n = 11$)	2035	33	1786	29	117	16
	86 y ($n = 20$)	2002	33	1768	29	115	15
BMI	25($n = 21$)	1917*	35*	1611***	29	120**	20**
	25 ($n = 10$)	2216	30	2117	29	107	7
Katz ADL-index	A−E ($n = 13$)	2016	34	1876	32*	109*	9*
	F−G ($n = 18$)	2012	32	1701	27	121	21
Eating	Independent ($n = 26$)	2003	33	1789	29	114	14
	Total help ($n = 5$)	2072	36	1698	30	123	23
Weight index	80 ($n = 10$)	1926	38*	1626	32	119	19
	80 ($n = 21$)	2055	31	1845	28	114	14
Diagnoses	Dementia ($n = 11$)	2147	33	1938	30	113	13
	Stroke ($n = 7$)	1872	28	1601	28	118	17
	Other ($n = 13$)	1977	33	1728	29	117	17

* $= P$ 0.05; ** $= P$ 0.01; *** $= P$ 0.001.
[a]Total water intake includes water from food, beverages and metabolic water oxidation.

Table 7 Cross-classification of water intake and labeled water estimated water loss by tertiles ($n = 31$)

	Labelled water estimated water loss (ml)		
Water intake (ml)	*1070–1607*	*1608–1887*	*1888–2580*
1123–1639	6	4	0
1640–1893	4	5	2
1894–2464	0	2	8

routine. One possible explanation for this consistent finding may lie in a systematic overreporting by the ward staff; it is also possible that standardized portion sizes overestimate consumed amounts. In this study, the high correlation ($r = 0.81$) between estimated energy intake and DLW could in part be explained by fewer errors in the food intake being made by the ward staff, who also functioned as independent observers and, thus, minimized the risk of patients altering self-reported dietary habits.

It has been previously suggested that a 7 day period is long enough to gain enough information about a food intake to be able to rank and categorize 80% of individuals correctly according to the distribution of energy-producing nutrients (fats, carbohydrates and protein) in their diets and overcome intra- and interpersonal variations in that distribution (Bingham, 1991). In our study, 80% of the patients were correctly classified in the lowest tertiles, and no subject was grossly misclassified by more than one tertile. Since the dietary record routine is intended to be used as an screening instrument to detect patients with malnutrition or at risk of becoming malnourished, it is vital to detect the patients with the lowest intake of energy.

Variations in the dilution space ratio in DLW measurements also seem to be statistically insignificant. The mean dilution space ratio coefficient in this study, 1.029, indicates that there is no systematic bias due to the DLW method. The preferable mean value remains questionable, although a value of 1.034–1.040 has been suggested as a suitable cut-off point (Speakman, 1997).

The difference between food-record reported energy intake and DLW-measured energy expenditure seems to be statistically insignificant with respect to age, ADL-independence dependence, and independence *vs* totally dependent during mealtime. There was a slight difference by gender, with a greater overestimate made for women; this difference may indicate that the staff believes that women patients eat more than they actually do. However, this difference disappeared when energy intake was related to body weight or energy expenditure. The difference was quite striking for patients with stroke compared with patients who had not had a stroke. The differences in energy intake and energy expenditure may be due to differences in body weight as well as diagnosis: six out of the seven patients with stroke had lower body weights, as indicated by BMI and weight index. Patients with a history of stroke were also more dependent for ADL functions: six out of the seven stroke patients had a score of F or G on the Katz ADL index. The differences for patients with a history of stroke may also be explained by communication problems and or lack of sufficient attention from the staff.

The study did not indicate whether the energy intake was appropriate for each patient. Thus, the findings cannot be used to determine whether the patients had adapted their physical activity to a lower energy intake or the energy intake is sufficient to support optimal physical activity. It is possible that institutionalized patients can adapt and maintain their energy balance at a suboptimal level. Compared with other studies involving free-living elderly given DLW, this is a low level of energy expenditure. Rothenberg (1997) found a mean energy expenditure of 9.9 MJ (9.6 MJ for women and 10.8 MJ for men) for 12 healthy elderly patients with a mean age of approximately 73 y. Similar values was noted by Pannemans and Westerterp (1995), who found a mean energy expenditure of 9.6 MJ in a group of free-living elderly. A higher mean energy expenditure (8.0 MJ) was reported for non-institutionalized patients with Alzheimer's disease (mean age: 73 y) and healthy elderly study participants (9.3 MJ; mean age: 69 y) (Poehlman *et al*, 1997) compared to this study.

Values for water intake estimated by the dietary record routine and labelled water estimated water loss was much closer. The mean water intake from food and beverages was 1787 ml; the mean water loss was 1774 ml. Using the DLW method, investigators were able to correctly classify 60% of the patients in the lowest tertiles and no patient was grossly misclassified by more than one tertile. There was no difference in the cross-classification when metabolic water was taken into account. We found no statistically significant difference between water intake and water loss in terms of gender, age, diagnoses, or independence *vs* total dependence at meals. A difference was determined in terms of body weight and ADL function, which might be explained by the fact that patients who are not mobile but can eat by themselves seem to get less fluid to drink. Patients who are mobile are able to get fluid by themselves and the totally dependent patients also seem to get enough fluid. Patients who are immobile but can eat without help seem not to get enough attention from the staff; this includes patients who have had a history of stroke. This finding is supported by Blower (1997), who showed that patients who where thirsty and unable to drink independently often waited to ask for help because they did not want to disturb the ward staff.

The group of geriatric patients in our study apparently had a sufficient intake of fluid. The mean water intake from food and beverages (including metabolic water oxidation) was 33 ml kg body weight per day; the recommended daily fluid intake for elderly adults is 30 ml kg body weight per day (Chernoff, 1995; Massler, 1985). Studies have shown that a large number of free-living and institutionalized elderly individuals do not get enough fluid, and this is associated with an increased mortality (Adams, 1988; Gaspar, 1988; Haveman-Nies *et al*, 1997). Risk factors for elderly patients developing dehydration include insufficient food and water intake, poor mobility, infection, fever, diarrhoea, vomiting, hospitalization, multiple diseases, and medications (Lavizzo-Mourey *et al*, 1988; Naitoh & Burrell, 1998; Weinberg *et al*, 1994a, b). Interestingly, these factors would contribute to a lack of body weight stability and keep the patient out of this study. Also, patients with cerebrovascular diseases, dementia and delirium have a higher incidence of dehydration (Albert *et al*, 1989; Holstein *et al*, 1994; Inouye *et al*, 1999). Total body water declines with age (Pfeil *et al*, 1995; Steen, 1997), and this decline could also be considered as a risk factor for dehydration.

The results of this study tells us something about how the energy intake matches the energy expenditure in a

group of body weight stable geriatric patients. The novel 7 day dietary record routine, based on standardized portion sizes and household measuring, is adopted to be used by ward staff in a real world clinical setting. The dietary record routine seems to be a valid instrument for assessing energy and water intake in geriatric patients and we believe that it could be applied in future studies.

Acknowledgements—We thank Vlasta Blabolil, dietician, for her skilful help during both the development and analysis of the dietary intake routine. The study was supported by grants from: Lund University, the Municipality of Malmö, Nutricia Nordica AB, Påhlsson's Foundation, the Swedish Foundation for Health Care Sciences and Allergy Research (grant no. V97 234), the Swedish Nutrition Foundation and the Swedish Society of Nursing.

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IV

Predicting Energy Needs in Geriatric Patients

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Abstract

Objective: To explore the accuracy of different equations for calculation and estimation of the basal metabolic rate to predict the total energy expenditure in combination with estimated physical activity level, using doubly labelled water as a reference method in geriatric patients.

Design: Total energy expenditure was measured with doubly labelled water. The physical activity level of each patient was estimated through observation. A literature search came up with 13 equations for basal metabolic rate or total energy expenditure developed for the elderly. These equations, in combination with estimated physical activity level, were tested against total energy expenditure measured with doubly labelled water.

Setting: Five nursing home wards in Sweden.

Subjects: Thirty-one geriatric patients, 18 women and 13 men, and with a mean age of 86 years.

Results: The mean daily measured total energy expenditure was 6.7 MJ and the mean estimated physical activity level was 1.2. Out of 13 equations, 6 managed to predict total energy expenditure in combination with physical activity level within the ±10% range and 4 within the ±5% range, 3 of which best predict total energy expenditure.

Conclusion: We have identified three equations for basal metabolic rate, which used in combination with estimated physical activity level, are the best predictors of total energy expenditure in geriatric patients.

Descriptors: Basal metabolic rate (BMR), doubly labelled water (DLW), energy requirements, geriatric patients, physical activity level (PAL), total energy expenditure (TEE).

Introduction

Different techniques are available to estimate total energy expenditure (TEE) in humans such as measurement of oxygen consumption, minute-by-minute heart rate monitoring, motion sensor techniques such as using the accelerometer, and the doubly labelled water (DLW) method (Schutz & Deurenberg, 1996). The gold standard today for estimating TEE in a real-life situation in humans is the DLW method (Schoeller, 1999). One of the advantages of DLW is that the etimate of TEE can be done in a person's normal life situation, in contrast to calorimetry, with which you are limited to laboratory settings (Schutz & Deurenberg, 1996). However, not many studies have thus far assessed TEE in frail elderly and geriatric patients.

Daily energy requirements can be defined as an individual's energy needs to support optimal physical functions. To correctly estimate patients' energy requirements is essential in providing an optimal nutritional care. An insufficient energy supply, as a result of incorrect recommendations for the elderly, can have considerable negative influence on a patient's health conditions.

In the report of a joint FAO/WHO/UNU Expert Consultation (FAO/WHO/UNU, 1985), the principle of relying on estimates of energy expenditure was adopted, rather than calculating energy intake from dietary surveys, for estimating energy requirements of adults. It was suggested that energy requirements could be expressed as multiples of the basal metabolic rate (BMR). The BMR of an individual can be defined as the minimal rate of energy expenditure compatible with life (Shetty et al, 1996). Basal metabolic rate can be measured under standard conditions or be calculated with a reasonable accuracy using different equations (McNeil, 2000). Since BMR constitutes about 60-80% of a person's TEE, it forms the basis for the assessment of energy requirements in adults (McNeil, 2000; Shetty et al, 1996).

In the FAO/WHO/UNU's method of estimating energy requirements, an assessment of the physical activity level (PAL) is also necessary. The PAL has been defined as TEE divided by the BMR (James et al, 1988). The energy cost, that is, the physical activity ration (PAR), of single activities such as sleeping, sitting and walking, could be added to a total sum for a 24-hour period and then divided by 24 to obtain an average PAL for the whole period (FAO/WHO/UNU, 1985). The FAO/WHO/UNU concept implies that the energy requirement can be estimated by multiplying the BMR with an appropriate activity factor.

Many equations have been published for predicting and calculating human energy requirements, especially in hospitalised patients (Foster et al, 1987), but not all of them can be applied to geriatric patients. The equations often use different variables in the estimation, such as anthropometric measurements, including mostly body weight (BW) and height, age, and sex. More than ten different equations adopted for the elderly have been published. To our knowledge, no previous study has compared

the accuracy of all these different equations in geriatric patients using one and the same reference method.

Body weight is closely associated with BMR and many studies have indicated that fat-free mass (FFM) has a high correlation with energy expenditure (Cunningham, 1991), at least in healthy and active, free-living younger adults (Westerterp et al, 1992). Fat-free mass can be defined as body mass minus body fat and is similar to, but not identical with, lean body mass (Steen, 1988). The effect of the FFM on BMR is mainly contributed by the metabolically active organs and muscles (FAO/WHO/UNU, 1985), with the brain, liver, kidneys and heart accounting for about 60% of the BMR in humans (Wang et al, 2001). However, energy expenditure can also be affected by physical activity (Sjödin et al, 1996) and gender (Carpenter et al, 1995; Dionne et al, 1999). Ageing is associated with a decrease in BMR that has been attributed to an age-related decline in FFM and an increase in body fat (Flynn et al, 1989; Keys et al, 1973). Some studies suggest that differences in FFM between younger and older people do not fully explain the differences in BMR and suggest that ageing is associated with an alternation in tissue energy metabolism (Fukagawa et al, 1990); however this has not yet been proven (Gallagher et al, 2000). In the elderly, not only FFM but also fat mass (FM), fat distribution, total body water (TBW), and aerobic capacity seem to have an influence on the BMR and the decline in BMR with age (Dionne et al, 1999; Fukagawa et al, 1996; Lührmann et al, 2001; Poehlman et al, 1992).

Body composition in humans changes throughout life (World Health Organization, 1995). Predictions of BMR and TEE can be influenced by body composition changes if these variables are included in the equations. Results of a longitudinal population study in Göteborg, Sweden, have shown changes in body composition with a decrease in BW, body height, and TBW from the age of 70 (Steen, 1988; Steen et al, 1985). The study showed a mean body height decrease of 4.9 cm in women and 4.0 cm in men, and a mean BW decrease of 5.1 kg in women and 3.2 kg in men between 70 and 95 years of age (Dey et al, 1999).

Aims

The aims of this study was to explore TEE levels in geriatric patients and to explore the accuracy of different equations for calculation of BMR to predict TEE, combined with the estimated PAL, using DLW as a reference method in geriatric patients.

Methods

Population

The study population was recruited from five nursing homes in a Swedish municipality. Inclusion criteria were nursing home residence, ability to orally ingest food and fluids, and a stable BW, defined as a maximum change of ±4% during the past 4 months or ±2% during the past 2 months. Exclusion criteria were parenteral or enteral nutrition, acute illness, inflammatory conditions, anaemia, hypo- or hyperthyroidism, protein-energy malnutrition (PEM) and terminal conditions, i.e. where death was expected within a few weeks. Criteria for PEM were based on weight index, triceps skinfold, arm muscle circumference, and serum albumin and serum prealbumin levels. A low value for three or more variables was used as an indicator of PEM (Persson et al, 2000). Blood samples were taken to measure albumin, prealbumin, haemoglobin, triiodothyronine, thyroid-stimulating hormone, prothrombin and orosomucoid.

Out of 102 patients, 37 matched the study criteria and agreed to participate in the study. Data are not available on six of the 37 as three patients later declined further participation in the study; in two patients it was impossible to get the required blood-samples; and in one patient there was no enrichment of the DLW probably due to a not properly consumed dose. Consequently, the study group consisted of 31 patients (18 women and 13 men) with a mean age of 86 years (see Table 1). The mean length of time patients had spent on the wards was 709 days (SD: ±531 days; range: 73 to 2346 days). The most common main diagnoses were dementia (n=11), stroke (n=7), neurological disorders (n=3), orthopaedic disorders (n=3) and others (n=7). According to the Katz ADL index (Brorsson & Hulter Åsberg, 1984; Katz et al, 1963), the participants were highly dependent on others in activities of daily living (ADL), as indicated by a score of F or G for 18 out of the 31 patients, five patients of whom were dependent in all activities. Only four patients were highly independent, as indicated by scores of A or B. The remaining nine patients had Katz ADL index scores of C or E. The mean BW was 55.8 kg for women and 69.8 kg for men (see Table 1). Mean body mass index (BMI) was 22.6 for women and 24.2 for men. Out of the 31 patients 26 had a BMI between 20 and 30 whereas five had a BMI <20 and none had a BMI >30. The mean change in BW during the study was -0.5 kg (SD: ±1.9 kg; SEM: 0.4 kg; n=29). Body weight for two patients was missing at the end of the study, as one patient died and another was relocated after the DLW sampling was finished and before BW was measured again. Body weight was also measured for a 3-months´ follow-up after the study.

Energy expenditure

The energy expenditure of each patient was measured using DLW with the stable isotopes deuterium (2H) and oxygen-18 (18O) (Prentice, 1990; Speakman, 1997).

Table 1. *Age, body height and weight, body fat mass (FM), fat free mass (FFM) and total body water (TBW) measured with doubly labelled water (DLW) and bioimpedance (BIA), mean values, SD (±) and range.*

Variables	Women (*n*=18)	Men (*n*=13)	All (*n*=31)
Age	87.5 ±6.0	82.9 ±7.3	85.6 ±6.8
range	71-96	65-92	65-96
Body height, cm	157.3 ±6.8	170.0 ±3.7	162.7 ±8.5
range	149.0-175.0	163.0-175.0	149.0-175.0
Body weight, kg	55.8 ±9.1	69.8 ±8.1	61.7 ±11.1
range	45.0-74.8	56.0-85.5	45.0-85.5
FM, kg (DLW)	20.0 ±6.0	23.7 ±5.9	21.5 ±6.1
range	11.5-30.5	15.5-37.6	11.5-37.6
FM, kg (BIA)	24.4 ±8.2	26.2 ±9.8	25.1 ±8.8
range	14.5-40.3	9.0-41.2	9.0-41.2
FM, % (DLW)	35.4 ±6.0	33.5 ±5.3	34.6 ±5.7
range	24.0-44.4	25.9-44.2	24.0-44.4
FM, % (BIA)	43.3 ±8.6	36.4 ±11.1	40.4 ±10.2
range	30.9-58.6	16.5-49.4	16.5-58.6
Mean differences FM, DLW- BIA (kg)	-4.3 ±3.9	-2.5 ±4.9	-3.6 ±4.4
FFM, kg (DLW)	35.7 ±4.7	46.4 ±4.2	40.2 ±6.9
range	29.0-45.7	38.2-52.3	29.0-52.3
FFM, kg (BIA)	30.9 ±4.4	44.1 ±4.8	36.4 ±8.0
range	24.2-40.2	35.1-51.8	24.2-51.8
Mean differences FFM, DLW- BIA (kg)	4.8 ±3.8	2.2 ±4.7	3.7 ±4.3
TBW, kg (DLW)	26.1 ±3.4	33.8 ±3.1	29.3 ±5.1
range	21.2-33.4	27.9-38.2	21.2-38.1
TBW, kg (BIA)	22.6 ±3.2	32.3 ±3.5	26.7 ±5.9
range	17.7-29.4	25.7-37.9	17.7-37.9
Mean differences TBW, DLW- BIA (kg)	3.5 ±2.8	1.6 ±3.5	2.7 ±3.2

The amount of isotope was calculated for each individual according to TBW, which was measured by bioelectric impedance analysis (BIA) (see below). The isotopes were administered as a mixture of 2H2O and H218O with a calculated initial excess body water enrichment of 150 ppm for 2H and 300 ppm for 18O. Individual doses were stored in airtight screw-cap glass containers at +4°C. The isotopes were given orally in water. The patients drank approximately 75 to 100 mL, then the sample bottle was rinsed with approximately 50 mL of tap water, which also was consumed.

The isotopes were given in the evening, just before the patients went to bed. Before each dose was administered, a background blood sample was collected from the subject. The first blood sample was collected before breakfast after an overnight fast without any food or fluid intake. The mean equilibration interval, the time between

isotope dosing and collection of the first blood sample, was 10.4 hours (SD: ±0.8 hours; range: 8.5 to 13.4 hours). The blood samples were taken by venipuncture using a vacuum system (Becton Dickinson sterile vacutainer® systems, Franklin Lakes, NJ, USA). Within half an hour after the sample was taken, the serum was separated by centrifuge for 10 minutes, then transferred to an airtight screw-cap glass container and immediately frozen to -20°C. A total of nine samples were taken from each patient: one sample before the dose, and one sample in the morning and one in the evening of days 1, 8, 15, and 22 of the study.

Sampling from the participants in DLW studies is often done of urine, however saliva, blood serum, or plasma have also been used (Prentice, 1990; Speakman, 1997). In a population of geriatric patients the prevalence of urine incontinence is usually high, with about 60% of the patients in Swedish nursing homes suffering from incontinence (Hedvall et al, 1994). For this reason, there are practical problems associated with obtaining urine samples at specific time intervals as the study protocol demands (Westerterp et al, 1995b). In this context, we decided to perform this study with blood samples, even though the invasive method of venipuncture could be annoying to the patients.

The samples were analysed by isotope ratio mass spectrometry (Aqua Sira, VG Isogas Ltd Middlewich, Cheshire, UK). Administration and analyses of the samples followed the Maastricht protocol (Westerterp et al, 1995b). In the calculation of energy expenditure, the individual changes in BW during the study have been taken into account.

Physical activity

The PAL was estimated through a combination of direct structured observation during several days by the first author (MP), of interviewing the ward staff who knew the patients well, and if possible, of interviewing the patients themselves. The patients' physical activity was measured and assessed on an 8-level scale (see Table 2). The PAR values used in this study were adopted from previous published studies on energy consumption (Calloway & Zanni, 1980; FAO/WHO/UNU, 1985; James & Schofield, 1990; Voorrips et al, 1993). Since studies have indicated that some standard physical activities, especially walking, call for more energy in elderly than in younger persons (Calloway & Zanni, 1980; Durnin & Mikulicic, 1956; Voorrips et al, 1993), the used PAR values were adjusted to more fit geriatric patients.

Basal metabolic rate equations

The BMR equations were compiled from references identified through a PubMed search and cross-referencing. The inclusion and exclusion criteria were determined from a clinical point of view, where the equation should be easy and practical to use on a daily basis. Inclusion criteria were that equations must be adopted for elderly women/men (>60 years of age) and predict BMR, resting metabolic rate (RMR),

Table 2. *Estimation of physical activity level (PAL). Adopted from (Calloway & Zanni, 1980; FAO/WHO/UNU, 1985; James & Schofield, 1990; Voorrips et al, 1993). PAR = physical activity ration.*

Activity	*PAR value*
Sleeping (Lying in bed without any physical activity)	**1.0**
Resting in bed (Lying in bed but not sleeping, engaging in light activity, such as eating, reading, watching TV)	**1.2**
Sitting (Sitting without any activity or with light activities such as: reading, watching TV, eating)	**1.3**
Standing (Light standing activities, such as cooking, dishing)	**1.6**
Driving a wheelchair (Sitting in a wheelchair and driving it manually with the arm/s and/or leg/s)	**3.0**
Walking (Walking activities, such as walking by yourself, or cleaning)	**4.0**
Moderate activities (Physical activities, such as cleaning windows, cleaning, vacuum-cleaning, making the bed, gardening including digging, shovelling snow, cycling, fast walking)	**5.0**
Heavy activities (Heavy activities, such as physical training, physical exercises, ball games, running, dancing)	**6.0**

or TEE. Equations exclusively developed for, and/or tested in, younger people (<60 years) were excluded, as were equations developed for one sex only, and equations that use values of biochemistry analysis or anthropometric measurements other than BW and height. Equations using direct or indirect calorimetry were likewise excluded. According to these criteria we identified eleven equations for calculation of BMR/RMR and two equations for calculation of TEE. Some equations have been published in a simplified version, but in this study we have only used the full length of the equations. Altogether, 13 equations were therefore included (see Table 3), and a description of the different study populations and reference methods is given in Table 4.

Body composition

Body composition was estimated both with anthropometric measurements (BW, height, triceps skinfold and arm muscle circumference), BIA (Lukaski et al, 1985; Steen et al, 1987), and with the DLW method (Prentice, 1990; Speakman, 1997).

Bioelectric impedance analysis with a BIA-109 (RJL Systems, Detroit, MI, USA) was done with the patient in a supine position and in according to the manufacturer's instructions. Body composition was calculated with measured resistance values using a computer software program provided by the manufacturer.

Table 3. *Equations for estimating basal metabolic rate (E1-E10 and E13) and total energy expenditure (E11-E12).*

E1: ***Harris & Benedict*** (kcal/24h) [191]
Women: 665.0955 + 9.5634 x BW (kg) + 1.8496 x H (cm) - 4.6756 x age (y)
Men: 66.4730 + 13.7516 x BW (kg) + 5.0033 x H (cm) - 6.7550 x age (y)

E2: ***FAO/WHO/UNU*** (kcal/24h) [94]
Women >60 y: 9.2 x BW (kg) + 637 x H (m) - 302
Men >60 y: 8.8 x BW (kg) + 1128 x H (m) - 1071

E3: ***FAO/WHO/UNU*** (MJ/24h) [94]
Women >60 y: 0.0439 x BW (kg) + 2.49
Men >60 y: 0.0565 x BW (kg) + 2.04

E4: ***Schofield*** (MJ/24h) [192]
Women >60 y: 0.038 x BW (kg) + 2.755
Men >60 y: 0.049 x BW (kg) + 2.459

E5: ***Schofield*** (MJ/24h) [192]
Women >60 y: 0.033 x BW (kg) + 1.917 x H (m) + 0.074
Men >60 y: 0.038 x BW (kg) + 4.068 x H (m) - 3.491

E6: ***Schofield modified*** (MJ/24h) [193]
Women 60-74 y: 0.0386 x BW (kg) + 2.875
Women ≥75 y: 0.0410 x BW (kg) + 2.610
Men 60-74 y: 0.0499 x BW (kg) + 2.930
Men ≥75 y: 0.0350 x BW (kg) + 3.434

E7: ***Owen et al*** (kcal/24h) [194, 195]
Women: 795 + 7.18 x BW (kg)
Men: 879 + 10.2 x BW (kg)

E8: Mifflin-St Jeor equations (kcal/24h) [196]
Women: 9.99 x BW (kg) + 6.25 x height (cm) - 4.92 x age - 161
Men: 9.99 x BW (kg) + 6.25 x height (cm) - 4.92 x age + 5

E9: ***Fredrix et al*** (kcal/24h) [197]
Women: 1641 + 10.7 x BW (kg) - 9.0 x age (y) - 406
Men: 1641 + 10.7 x BW (kg) - 9.0 x age (y) - 203

E10: ***Westerterp et al*** [198]
Step 1. Fat-free mass (FFM) in kg
Women: -12.47 - 0.074 x age (y) + 27.392 x H (m) + 0.218 x BW (kg)
Men: -18.36 - 0.105 x age (y) + 34.009 x H (m) + 0.292 x BW (kg)
Step 2. Fat mass (FM) in kg
BW (kg) - FFM (kg)
Step 3. Basal metabolic rate (MJ/day)
0.102 x FFM (kg) + 0.024 x FM (kg) + 0.85

E11: ***Vinken et al*** (TEE MJ/24h) [199]
Women: 7.377 - 0.073 x age (y) + 0.0806 x BW (kg) + 0.0135 x H (cm) - 1.363
Men: 7.377 - 0.073 x age (y) + 0.0806 x BW (kg) + 0.0135 x H (cm)

E12: ***Poehlman & Dvorak*** (TEE MJ/24h) [200]
0.141 x BW (kg) - 0.720

E13: ***Lührmann et al*** (kJ/24h) [201]
Women: 3169 + 50.0 x BW (kg) - 15.3 x age (y)
Men: 3169 + 50.0 x BW (kg) - 15.3 x age (y) + 746

BW = body weight
H = Height
y = years

BMR/TEE expressed as kcal has been converted into MJ by multiplying with 0.004184.

Table 4. Background data for the equations of BMR (E1-E10) and TEE (E11-12) included in this study as presented in the original publications.

Equation number	Publication year	*n*	Number of female (F) and male (M) participants	Mean age, years, SD (±), range	Mean body-weight in kg, SD (±)	Mean height in cm, SD (±)	Number of participants ≥60y	Methods used
E1	1919 (series I)	239	F 103 M 136	31 ±14 (15-74) 27 ±9 (16-63)	55.9 ±11.5 63.9 ±10.3	162.0 ±5.2 172.9 ±7.6	6 3	Indirect calorimetry
	1928 (series II)	60	F 33 M 27	32 ±12 (18-58) 34 ±16 (21-89)	63.4 ±12.0 71.5 ±20.3	161.4 ±6.0 173.5 ±8.1	0 3	
	1935 (Bangor series)	38	F 33 M 5	77 ±6 (66-88) 81 ±7 (74-87)	55.5 ±11.9 66.5 ±10.3	154.0 ±7.1 171.0 ±4.2	33 5	
E2 **E3**	1985	11937	F 4315 M 7622	all ages	*	*	* [1]	Meta analysis of 114 studies, mostly using indirect calorimetry
E4	1985	7173	F 2364	all ages	*	*	*	Meta analysis of different studies [5]
E5			M 4809	all ages	*	*	*	
			F 38 [2]	66 ±5 [4]	55.5 ±10.9	153.0 ±8.5	38	
			M 50 [3]	72 ±10 [4]	62.3 ±12.8	165.0 ±8.0	50	
E6	1991	>451	F >180	≥60	*	*	>180	Data on method not given [6]
			M >271	≥60	*	*	>271	
E7	1986	44	F 44	35 ±12 (18-65)	74.9 ±24.6	164.0 ±6.8	1	Indirect calorimetry
	1987	60	M 60	38 ±16 (18-82)	86.6 ±23.8	175.0 ±6.9	9	
E8	1990	498	F 247	44 ±14 (20-76)	70.2 ±14.1	164.2 ±6.3	*	Indirect calorimetry
			M 251	44 ±14 (19-76)	87.5 ±14.4	178.3 ±6.8	*	
E9	1990	40	F 22	66 ±7 (51-82) [7]	64.8 ±7.1	*	*	Indirect calorimetry
			M 18	63 ±8 (51-82) [7]	81.1 ±11.0	*	*	
E10	1995	190	F 105	42 ±20 (20-95)	62.0 ±16.0	163.0 ±8.0	*	DLW and other methods [8]
			M 85	41 ±19 (19-80)	80.0 ±24.0	177.0 ±8.0		
E11	1999	93	F 49, M 44	(18-81)	*	*	30	Indirect calorimetry, DLW, activity monitors, self reported activity
			F 10 [9]	74 ±4 (68-80)	58.5 ±9.9	155.3 ±4.7	10	
			M 20 [10]	68 ±6 (60-81)	78.3 ±12.9	176.4 ±5.8	20	
E12	2000	30	F 17, M 13	73 ±8 [3]	65 ±11.0	*	*	Indirect calorimetry, DLW
E13	2002	286	F 179	67.8 ±5.7	67.5 ±10.0	159.9 ±5.5	179	Indirect calorimetry.
			M 107	66.9 ±5.1	78.8 ±9.7	173.0 ±6.5	107	

** Data not given. [1] Out of the 114 studies 17 included people >60 years of age. [2] Women >60 y also included in the total number of women (n=2364). [3] Men >60 y also included in the total number of men (n=4809). [4] Age range not given. [5] An anothed bibliography has been published over studies used. [6] Based on Schofield 1985 (38 women and 50 men >60 y) with new unpublished data added (180 women and 271 men) and some of the original subjects excluded (number not given). [7] Age range not given sex specific. [8] A mathematical simulation model based on a meta analysis of 11 different studies using doubly labeled water and other techniques. [9] Women >60 y also included in the total number of women (n=49). [10] Men >60 y also included in the total number of men (n=44).*

Total body water was measured by deuterium dilution as part of the DLW measurements (Marken Lichtenbelt et al, 1994; Westerterp, 1999; Westerterp et al, 1995b). Assuming a two-compartment model of FM and FFM, the FFM was calculated assuming a hydration factor of 73% for TBW.

Fever

During the study period, nursing charts were monitored for fluctuations in the patients' body temperature. We did not take any initiative to measure the patients' body temperature, but noted the body temperature recorded by nursing staff as part of the normal nursing care routine. Fever is in this study defined as a measured body temperature ≥37.8°C (Castle et al, 1993).

Ethics

Each patient and/or a close relative gave an oral informed consent to the patient's participation in the study. The study was approved by the Local Ethical Committee at Lund University, Sweden.

Statistics

Statistical analyses were performed using SPSS for Windows (10.0 ed., SPSS Inc; Chicago, IL, USA, 1999). Values are expressed as means and SD. In the subgroup analysis (Tables 6-11), the variables age and PAL were divided by the median value. Since samples were small and not normally distributed, nonparametric methods were used for analysing data (Altman, 1996). The relationship between measured TEE and calculated energy expenditure was examined using two-tailed Spearman's Rank Correlation Coefficient and Root Mean Square Error (RMSE) (Guo & Chulea, 1996). Cross-classification by tertiles was examined using chi-squared test and Kendall's Tau-b value. The Mann-Withney U-test was used to explore differences between patients with and patients without fever. Results were considered statistically significant if P values were <0.05.

Results

Measured total energy expenditure

The mean TEE of the patients, according to DLW measurements, was 6.67 MJ (SD ±1.39 MJ; range 4.22-9.58 MJ), 6.08 MJ (SD ± 1.14; range 4.22-8.70 MJ) in women, and 7.49 MJ (SD ±1.33 MJ; range 5.25-9.58 MJ) in men. Mean TEE/kg BW in the patients was 26.0 kcal (SD ±3.7 kcal; range 19.0-33.6 kcal), 26.2 kcal (SD±3.7 kcal; range 21.1-33.6 kcal) in women, and 25.7 kcal (SD ±3.8 kcal; range 19.1-31.4 kcal) in men.

Physical activity

The mean estimated PAL of the patients was 1.20 (SD ±0.12; range 1.01-1.41), 1.22 (SD ±0.12; range 1.09-1.41) in women, and 1.18 (SD ±0.12; range1.01-1.40;) in men. The range of the day-to-day variation in the patients' physical activity was small. The patients' activities were mainly sleeping, resting in bed, and sitting. No patient took part in any moderate or heavy activities and no patient was receiving any regular physical rehabilitation or training. Only one of the patients took part in normal daily activities in the wards, such as setting the table for dinner or doing the dishes. Out of the 31 patients, 13 were dependent on a wheelchair for getting about, eight of which were able to drive the wheelchair by themselves. Only three of the patients could walk by themselves without any technical or personal aid, while nine patients were able to walk with a rollator and two with the assistance of nursing staff. Out of the 31 patients, four were bedridden most of the time and only got out of bed for a few hours each week.

Calculated energy expenditure

The eleven equations used for prediction of BMR in combination with estimated PAL and the two equations used for predicting TEE were been compared with DLW-measured TEE. The 13 equations were compared with mean TEE results for the whole group (see Table 5) and separately for the women (see Table 6) and men (see Table 7). The equations were also compared with the subgroup analysis of low and high PAL with a cut-off at PAL 1.2 (see Tables 8 and 9) as well as low and high age, with a cut-off at 86 years (see Tables 10 and 11). Only seven (E2, E4, E5, E6, E7, E10, E13) out of the 13 tested equations, in combination with estimated PAL, managed to predict TEE within a ±10% range in all of the analyses and four of these (E2, E5, E7, E10) could predict TEE within a range of ±5%. The three equations in combination with estimated PAL that best predicted TEE for both women and men with high and low PAL and high and low age were: E10 (Westerterp et al, 1995a); E2 (FAO/WHO/UNU, 1985) using both BW and height, and E7 (Owen et al, 1986; Owen et al, 1987) using only BW.

Table 5. *Mean calculated energy expenditure with the different equations including measured PAL compared with DLW measured TEE as reference in* ***all patients*** *(n=31).*

	Mean and SD (±) (MJ/24h)	Range (MJ/24h)	Mean difference E1-E13 and TEE (MJ/24h)	Range difference (MJ/24h)	Difference (%) E1-E13 and TEE	RMSE* (MJ)	Spearman's correlation coefficents E1-E13 and TEE *P*=<0.01
E1	5.92 ±0-95	4.55-8.41	-0.75	-2.68 -- +0.54	-12.7	1.06	0.88
E2	6.61 ±0.95	5.07-9.07	-0.07	-2.39 -- +1.30	-1.0	0.77	0.87
E3	6.24 ±0.90	5.03-8.40	-0.43	-2.75 -- +1.21	-6.9	0.94	0.80
E4	6.36 ±1.00	5.01-8.93	-0.31	-2.35 -- +1.21	-4.9	0.82	0.83
E5	6.49 ±0.97	5.01-9.04	-0.19	-2.39 -- +1.14	-2.9	0.79	0.86
E6	6.40 ±0.95	5.00-8.72	-0.27	-2.40 -- +1.20	-4.2	0.78	0.87
E7	6.83 ±1.23	5.01-9.92	+0.16	-1.44 -- +1.56	+2.3	0.77	0.83
E8	5.61 ±1.21	5.22-8.45	-1.06	-2.63 -- +0.41	-18.9	1.31	0.85
E9	6.07 ±1.23	3.85-8.90	-0.61	-2.06 -- +0.65	-10.0	0.94	0.86
E10	6.77 ±1.17	4.11-9.74	+0.10	-1.69 -- +1.38	+1.4	0.71	0.86
E11	7.51 ±1.69	5.00-9.99	+0.83	-1.32 -- +3.53	+12.5	1.54	0.70
E12	7.98 ±1.56	5.62-11.34	+1.31	-0.70 -- +3.34	+19.6	1.72	0.70
E13	6.29 ±1.21	4.56-9.14	-0.38	-1.77 -- +0.78	-6.1	0.77	0.86
TEE	6.67 ±1.39	4.22-9.58					

* Root mean square error

Cross-tabulation by tertiles of the three best predictive equations showed that E7 (Owen et al, 1986; Owen et al, 1987) classified 74% of the patients correctly, eight out of eleven were correctly classified in the lowest tertile and nine out of ten were correctly classified in the highest tertile. None was misclassified by more than one tertile and Kendall's Tau-b value was 0.75. The other two equations E10 (Westerterp et al, 1995a) and E2 (FAO/WHO/UNU, 1985), using cross-tabulation by tertiles, correctly classified 68% of the patients, seven out of eleven were correctly classified in the lowest tertile and nine out of ten were correctly classified in the highest tertile. None was misclassified by more than one tertile and Kendall's Tau-b value was 0.69.

Body composition

Bioelectric impedance analysis overestimated FM measured with DLW by 16.7%, underestimated FFM by 10.4%, and underestimated TBW by 9.7% (see Table 1). The best correlation for DLW-measured TEE was seen in DLW-measured FFM and TBW (r= 0.83) (see Table 12). The correlation between BIA and DLW-measured TEE was fair in the whole group (r =0.41-0.60), but poor in separately analysing women and men (see Table 12). The 3-month follow-up after the DLW study showed no statistical difference in BW changes between the patients with a low PAL (<1.2) and those with a high PAL (≥1.2). Both groups gained BW during the 2 months before and 3 months after the DLW measurements (mean total time = 165

***Table 6**. Mean calculated energy expenditure with the different equations including measured PAL compared with DLW-measured TEE as reference in **women** (n=18). P-values are given as *=P<0.05, **=P<0.01, and ***=P<0.001.*

	Mean and SD (±) (MJ/24h)	Range (MJ/24h)	Mean difference E1-E123 and TEE (MJ/24h)	Range difference (MJ/24h)	Difference (%) E1-E13 and TEE	Spearman's correlation coefficients E1-E13 and TEE
E1	5.51 ±0.75	4.55-6.98	-0.57	-1.76 -- +0.54	-10.4	0.77***
E2	6.18 ±0.79	5.07-7.95	+0.10	-0.75 -- +1.30	+1.7	0.82***
E3	6.02 ±0.81	5.03-7.71	-0.06	-1.00 -- +1.21	-1.0	0.74***
E4	5.94 ±0.76	5.01-7.47	-0.14	-1.23 -- +1.21	-2.3	0.74***
E5	6.00 ±0.73	5.00-7.56	-0.08	-1.14 -- +1.14	-1,2	0.81***
E6	5.98 ±0.79	5.01-7.58	-0.10	-1.12 -- +1.20	-1.7	0.72***
E7	6.09 ±0.71	5.22-7.47	+0.02	-1.26 -- +1.47	+0.3	0.76***
E8	4.83 ±0.75	3.856.38	-1.25	-2.32 -- -0.14	-25.8	0.82***
E9	5.32 ±0.81	4.11-6.87	-0.76	-2.06 -- +0.65	-14.2	0.75***
E10	6.11 ±0.80	5.03-7.85	-0.04	-0.85 -- +1.11	+0.6	0.80***
E11	6.25 ±0.94	5.00-8.39	+0.17	-1.32 -- +2.40	+2.8	0.57*
E12	7.15 ±1.29	5.62-9.82	+1.07	-0.70 -- +3.03	+17.6	0.56*
E13	5.61 ±0.83	4.22-7.26	-0.47	-1.45 -- +0.60	-8.4%	0.77**
TEE	6.08 ±1.14	4.22-8.70				

***Table 7**. Mean calculated energy expenditure with the different equations including measured PAL compared with DLW-measured TEE as reference in **men** (n=13). P-values are given as *=P<0.05, **=P<0.01, and ***=P<0.001.*

	Mean and SD (±) (MJ/24h)	Range (MJ/24h)	Mean difference E1-E13 and TEE (MJ/24h)	Range difference (MJ/24h)	Difference (%) E1-E13 and TEE	Spearman's correlation coefficients E1-E13 and TEE
E1	6.50 ±0.92	5.32-8.41	-1.00	-2.68 -- +0.13	-15.4	0.85***
E2	7.19 ±0.85	6.12-9.07	-0.30	-2.39 -- +1.05	-4.2	0.80***
E3	6.55 ±0.95	5.32-8.40	-0.94	-2.75 -- +0.21	-14.4	0.80***
E4	6.94 ±1.03	5.59-8.93	-0.56	-2.35 -- +0.57	-8.1	0.80***
E5	7.15 ±0.87	6.05-9.04	-0.34	-2.39 -- +0.97	-4.8	0.80***
E6	6.99 ±0.86	5.82-8.72	-0.51	-2.40 -- +0.57	-7.2	0.86***
E7	7.85 ±1.07	6.52-9.92	+0.35	-1.44 -- +1.56	+4.7	0.77***
E8	6.68 ±0.83	5.66-8.45	-0.81	-2.63 -- +0.41	-12.1	0.83***
E9	7.09 ±0.93	5.81-8.90	-0.40	-1.93 -- +0.56	-5.7	0.93***
E10	7.67 ±0.99	6.52-9.74	+0.18	-1.69 -- +1.38	+2.4	0.80***
E11	9.25 ±0.53	8.06-9.99	+1.75	+0.22 -- +3.53	+23.4	0.67*
E12	9.13 ±1.14	7.17-11.34	+1.63	-0.03 -- +3.34	+21.8	0.59*
E13	7.23 ±1.01	5.93-9.14	-0.26	-1.77 -- +0.78	-3.6	0.85**
TEE	7.49 ±1.33	5.25-9.58				

Table 8. *Mean calculated energy expenditure with the different equations including measured PAL compared with DLW-measured TEE as reference in patients with* ***low physical activity****, PAL<1.2 (n=16).*

	Mean and SD (±) (MJ/24h)	Range (MJ/24h)	Mean difference E1-E13 and TEE (MJ/24h)	Range difference (MJ/24h)	Difference (%) E1-E13 and TEE	Spearman's correlation coefficients E1-E13 and TEE *P*=<0.01
E1	5.45 ±0.71	4.55-7.16	-0.65	-1.87 -- +0.33	-11.9	0.87
E2	6.16 ±0.73	5.07-7.71	+0.07	-1.27 -- +1.30	+1.0	0.79
E3	5.67 ±0.58	5.03-7.19	-0.43	-2.04 -- +0.82	-7.5	0.74
E4	5.81 ±0.73	5.01-7.66	-0.28	-1.72 -- +0.82	-4.9	0.75
E5	6.05 ±0.76	5.00-7.69	-0.05	-1.33 -- +1.13	-0.9	0.78
E6	5.89 ±0.72	5.01-7.40	-0.21	-1.15 -- +0.81	-3.6	0.82
E7	6.33 ±1.01	5.22-8.44	+0.23	-0.83 -- +1.34	+3.8	0.73
E8	5.29 ±1.03	3.85-7.13	-0.81	-1.64 -- +0.41	-15.3	0.83
E9	5.62 ±1.01	4.11-7.44	-0.47	-1.42 -- +0.56	-8.4	0.84
E10	6.31 ±0.95	5.03-8.28	+0.21	-0.87 -- +1.28	+3.5	0.78
E11	7.64 ±1.65	5.02-9.99	+1.54	+0.15 -- +3.53	+25.3	0.82
E12	7.83± 1.52	5.62-11.34	+1.74	+0.27 -- +3.34	+28.5	0.67
E13	5.79 ±0.97	4.56-7.82	-0.31	-1.31 -- +0.68	-5.3%	0.81
TEE	6.10 ±1.03	4.22-8.05				

Table 9. *Mean calculated energy expenditure with the different equations including measured PAL compared with DLW-measured TEE as reference in patients with* ***high physical activity****, PAL ≥1.2 (n=15).*

	Mean and SD (±) (MJ/24h)	Range (MJ/24h)	Mean difference E1-E13 and TEE (MJ/24h)	Range difference (MJ/24h)	Difference (%) E1-E13 and TEE	Spearman's correlation coefficients E1-E13 and TEE *P*=<0.01
E1	6.43±0.94	5.64-8.41	-0.86	-2.68 -- +0.54	-13.4	0.81
E2	7.08 ±0.95	5.68-9.07	-0.21	-2.39 -- + 1.17	-2.9	0.84
E3	6.85 ±0.77	5.68-8.40	-0.43	-2.75 -- +1.21	-6.3	0.83
E4	6.94 ±0.93	5.68-8.93	-0.35	-2.35 -- +1.21	-5.0	0.85
E5	6.95 ±0.96	5.61-9.04	-0.33	-2.39 -- +1.14	-4.8	0.83
E6	6.95 ±0.88	5.67-8.72	-0.34	-2.40 -- +1.20	-4.9	0.81
E7	7.37 ±1.25	5.94-9.92	-0.08	-1.44 -- +1.56	+1.1	0.88
E8	5.95 ±1.32	4.09-8.45	-1.34	-2.63 -- +0.09	-22.4	0.81
E9	6.54 ±1.29	4.74-8.90	-0.75	-2.06 -- +0.65	-11.5	0.82
E10	7.26 ±1.22	5.56-9.74	-0.03	-1.69 -- +1.38	-0.4	0.83
E11	7.37 ±1.79	5.00-9.87	+0.08	-1.32 -- +2.40	+1.1	0.77
E12	8.13 ±1.63	5.73-10.60	+0.85	-0.70 -- +2.86	+11.6	0.72
E13	6.82 ±1.24	5.07-9.14	-0.46	-1.77 -- +0.78	-6.8%	0.82
TEE	7.29 ±1.49	4.47-9.58				

Table 10. *Mean calculated energy expenditure with the different equations including measured PAL compared with DLW-measured TEE as reference in* ***younger patients*** *65-86 years (n=16). P-values are given as *=P<0.05, **=P<0.01, and ***=P<0.001.*

	Mean and SD (±) (MJ/24h)	Range (MJ/24h)	Mean difference E1-E13 and TEE (MJ/24h)	Range difference (MJ/24h)	Difference (%) E1-E13 and TEE	Spearman's correlation coefficients E1-E13 and TEE
E1	6.16 ±1.00	4.88-8.41	-0.81	-2.68 -- +0.38	-13.1	0.82***
E2	6.79 ±0.99	5.37-9.07	-0.17	-2.39 -- +1.05	-2.5	0.83***
E3	6.30 ±1.00	5.13-8.40	-0.66	-2.75 -- +0.57	-10.5	0.80***
E4	6.47 ±1.11	5.10-8.93	-0.49	-2.35 -- +0.57	-7.5	0.82***
E5	6.67 ±1.03	5.24-9.04	-0.29	-2.39 -- +0.97	-4.3	0.83***
E6	6.56 ±1.04	5.10-8.72	-0.40	-2.40 -- +0.60	-6.1	0.87***
E7	7.06 ±1.35	5.28-9.92	+0.10	-1.44 -- +1.56	+1.4	0.84***
E8	6.01 ±1.17	4.31-8.45	-0.95	-2.63 -- +0.41	-15.8	0.84***
E9	6.49 ±1.24	4.69-8.90	-0.47	-1.93 -- +0.65	-7.3	0.84***
E10	7.04 ±1.21	5.35-9.74	+0.08	-1.69 -- +1.38	+1.2	0.85***
E11	8.22 ±1.40	6.15-9.87	+1.26	-1.04 -- +3.53	+18.0	0.68***
E12	8.19 ±1.24	6.38-10.60	+1.23	-0.03 -- +3.34	+17.7	0.60*
E13	6.58 ±1.27	4.80-9.14	-0.38	-1.77 -- +0.78	-5.8	0.83**
TEE	6.96 ±1.40	4.80-9.58				

Table 11. *Mean calculated energy expenditure with the different equations including measured PAL compared with DLW-measured TEE as reference in* ***older patients*** *87-96 years (n=15).*

	Mean and SD (±) (MJ/24h)	Range (MJ/24h)	Mean difference E1-E13 and TEE (MJ/24h)	Range difference (MJ/24h)	Difference (%) E1-E13 and TEE	Spearman's correlation coefficients E1-E13 and TEE *P*=<0.01
E1	5.67 ±0.87	4.55-7.16	-0.69	-1.83 -- +0.54	-12.2	0.92
E2	6.41 ±0.90	5.07-7.95	+0.04	-1.15 -- +1.30	+0.7	0.90
E3	6.18 ±0.81	5.03-7.71	-0.18	-1.51 -- +1.21	-3.0	0.90
E4	6.23 ±0.89	5.01-7.87	-0.13	-1.23 -- +1.21	-2.1	0.90
E5	6.29 ±0.89	5.00-7.79	-0.08	-1.14 -- +1.14	-1.2	0.87
E6	6.23 ±0.86	5.01-7.77	-0.13	-1.16 -- +1.20	-2.1	0.90
E7	6.58 ±1.08	5.22-8.83	+0.22	-1.26 -- +1.47	+3.5	0.85
E8	5.18 ±1.14	3.85-7.23	-1.18	-2.32 -- -0.14	-22.8	0.84
E9	5.61 ±1.09	4.11-7.73	-0.75	-2.06 -- +0.27	-13.4	0.88
E10	6.47 ±1.08	5.03-8.44	+0.11	-0.85 -- +1.11	+1.7	0.84
E11	6.75 ±1.69	5.00-9.99	+0.38	-1.32 -- +5.58	+6.0	0.71
E12	7.75 ±1.87	5.62-11.34	+1.39	-0.70 -- +3.29	+21.8	0.79
E13	5.98 ±1.0	4.56-8.06	-0.39	-1.45 -- +0.60	-6.5	0.88
TEE	6.36 ±1.37	4.22-8.93				

days). The group with a low PAL (n=13) had a mean weight gain of +1.0 kg and the group with a high PAL had a mean weight gain of + 0.1 kg (n=14). Data on four patients are missing due to death, illness, or relocation.

Fever

During the time period of DLW measuring, four patients had a nursing chart recording of fever. In three out of the four patients, the fever lasted for a maximum of 2 days and one patient had a temperature for a total of 6 days. In none of the patients did the body temperature exceed 39.0°C. Mean TEE measured with DLW was 6.70 MJ in patients without fever and 6.47 MJ in patients with a fever. There was no statistically significant difference between patients with and patients without a fever in either measured or calculated TEE. However, there was a significant difference in estimated PAL (P<0.05). Mean PAL in patients with fever was 1.10 and in patients without, 1.22.

Table 12. *Correlation between TEE measured with doubly labeled water (DLW) and age, height, body weight, total body water (TBW) measured with bioimpedance (BIA) and DLW, fat mass (FM) measured with BIA and DLW, fat free mass (FFM) measured with BIA and DLW, basal metabolic rate (BMR) measured with BIA and estimated physical activity level (PAL). Spearmans correlation coefficients (r) are given and P-values are given as *=P<0.05, **=P<0.01 and ***=P<0.001.*

	All *r* (*n*=31)	**Female** *r* (*n*=18)	**Male** *r* (*n*=13)
Age	-0.24	-0.52	-0.13
Height	0.35	0.32	-0.71**
Body weight	0.70**	0.56*	0.59*
TBW (BIA)	0.55**	0.28	0.06
TBW (DLW)	0.83**	0.83**	0.78**
FM (BIA)	0.41*	0.47	0.33
FM (DLW)	0.40*	0.25	0.34
FFM (BIA)	0.55**	0.28	0.06
FFM (DLW)	0.83**	0.83**	0.78**
BMR (BIA)	0.60**	0.42	0.19
PAL	0.46**	0.53*	0.80**

Table 22. Doubly labelled water studies in elderly subjects, mean values and SD (±) (paper V).

	n	Mean age (years), number of female (F) and male (M) participants	Mean TEE (MJ)	Mean PAL	Subjects
Prentice et al 1989 [219]	14	14 F 79.0 ±0.0	6.10 ±0.00	1.51	Dementia and depression long-stay in-patients
Goran et al 1992 [281]	13	6 F 64.0 ±5.0 7 M 68.0 ±6.0	8.75 ±0.97 11.19 ±1.65	1.42† 1.56†	Healthy free-living elderly
Roberts et al [282]	15	15 M 69.2 ±1.8	10.44 ±0.38	1.75	Healthy free-living elderly
Reilly et al 1993 [283]	11	11 F 73.0 ±3.0	9.21 ±1.48	1.80	Healthy free-living elderly
Pannemans et al 1995 [284]	26	10 F 67.6 ±4.1 16 M 71.4 ±4.9	9.60 ±1.56§	1.66 1.52	Healthy free-living elderly
Sawaya et al 1995 [285]	10	10 F 74.0 ±1.4	7.59 ±0.28	1.58†	Healthy free-living elderly
Fuller et al 1996 [286]	23	23 M 82.0 ±3.0	9.20 ±1.4	1.50	Healthy free-living elderly
Morio et al 1997 [287]	12	6 F 71.3 ±2.4 6 M 68.8 ±2.5	9.60 ±0.8 12.80 ±3.1	1.76† 1.81†	Healthy free-living elderly
Poehlman et al 1997 [288]	30	17 F/13 M 73.0 ±8.0§	7.95±2.16§	1.48†§	Free-living Alzheimer's patients
Poehlman et al 1997 [288]	103	52 F/51 M 69.0 ±7.0§	9.26 ±2.15§	1.56†§	Healthy free-living elderly
Toth et al 1997 [289]	16	16 M 62.0 ±8.0	9.26 ±1.92	1.34†	Free-living Parkinson's disease patients
Toth et al 1997 [290]	12	1 F/11 M 73.0 ±6.0§	7.82 ±1.45§	1.32†	Free-living cachetic heart failure patients
Toth et al 1997 [290]	13	13 M 67.0 ±5.0	9.83 ±2.28	1.38†	Free-living non-cachetic heart failure patients
Rothenberg et al 1998 [84]	12	9 W 73.0 ±0 3 M 73.0 ±0	9.60 ±1.16 10.79 ±2.05	1.72 1.74	Healthy free-living elderly

Starling et al 1998 [85]	99	51 F 67.0 ±6.0 48 M 70.0 ±7.0	9.65 ±2.71 10.28 ±2.79	1.63 1.73	Healthy free-living elderly
Starling et al 1998 [291]	65	37 F 64.0 ±8.0 28 M 64.0 ±7.0	8.74 ±1.72 11.60 ±2.33	1.51 1.71	Healthy free-living elderly
Kaczkowski et al 2000 [292]	76	76 F 67.3 ±11.5	10.02 ±3.12	missing	Healthy free-living elderly
Rothenberg et al 2000 [224]	21	13 F 91-96 y 8 M 91-96 y	6.30 ±0.81 8.10 ±0.73	1.19 1.36	Healthy free-living elderly
Seale et al 2002 [86]	27	13 F 73.5 ±4.2 14 M 74.1 ±4.1	9.44 ±0.90 12.43 ±1.63	1.82† 1.83†	Healthy free-living elderly
Present study	11	5 F 86.4 ±3.6 6 M 84.2 ±4.6	6.69 ±0.89 8.26 ±1.04	1.30 1.25	Dementia nursing-home patients
Present study	7	4 F 83.3 ±9.4 3 M 81.0 ±14.2	5.13 ±0.66 5.90 ±0.61	1.16 1.06	Stroke nursing-home patients
Present study	13	9 F 90.0 ±4.4 4 M 82.5 ±6.2	6.16 ±1.23 7.55 ±1.12	1.20 1.16	Geriatric nursing-home patients
Total	629	≈74	8.91	1.51	
		F 188 76.3	7.92	1.51	Only with complete sex specific data included
		M 194 74.2	9.83	1.51	Only with complete sex specific data included
Exclusive present study	598	≈72	9.44	1.58	
		F 170 73.2	8.50	1.59	Only with complete sex specific data included
		M 181 72.0	10.54	1.61	Only with complete sex specific data included

† Value not given, calculated from mean
§ Sex specific values not given

Discussion

We used 13 different equations for prediction of BMR/TEE and compared them with DLW-measured TEE. Only three of the equations proved to give accurate estimations in geriatric patients taking age, sex and physical activity into consideration.

The mean daily TEE of the patients, according to DLW measurements in this study, was 6.67 MJ and mean PAL was 1.20. Compared with other DLW studies involving elderly, these results show relatively low levels of TEE and PAL. A summary of 17 DLW studies gives a mean TEE of 9.44 MJ and a mean PAL of 1.58 in a total of 598 participants (see Table 13). Some of the studies in Table 13 included also middle-aged people and in all studies but one, the participants were younger than the participants were in our study. The only study with comparable figures for TEE and PAL is presented by Rothenberg et al (Rothenberg et al, 2000) who have studied TEE in 91-96-year-old, free-living elderly and even though the mean age in our study was lower, other factors, such as activity and anthropometry patterns, seem comparable. Only a few DLW studies have been published on hospitalised geriatric patients. Prentice et al (Prentice et al, 1989) found a mean energy expenditure of 6.10 MJ and a mean PAL of 1.51 in 14 elderly institutionalised female mental patients with a mean age of 79 years. However, low PAL values have been reported in institutionalised elderly when using indirect calorimetry. Ozeki et al (Ozeki et al, 2000) report a mean PAL of 1.26 (1.01-1.57) in 113 elderly (mean age 79 years), institutionalised Japanese women, 64% of whom had a PAL <1.3.

Minute-by-minute heart rate monitoring in geriatric patients to measure energy expenditure resulted in a higher estimated PAL than seen in the present study. In a study by Elmståhl (Elmståhl, 1987), 30 geriatric patients in long-term care with a mean age 83 years had a mean estimated PAL of 1.48. However, 40% of the patients in Elmståhl's study had regular physiotherapy as compared with none in the present study, which could at least in part explain the higher PAL value. Rothenberg et al (Rothenberg et al, 1998) simultaneously measured energy expenditure using both heart rate monitoring and DLW in twelve free-living elderly and report an estimated mean PAL of 1.73 from DLW measurements and 1.55 using heart rate monitoring.

Only a few studies have measured the energy consumption of standard physical activities in elderly compared with younger persons. Results from these studies indicate that some standard physical activities, especially walking, call for more energy in elderly than in younger persons, while in activities that only use one arm, no significant difference in energy consumption is found (Calloway & Zanni, 1980; Durnin & Mikulicic, 1956; Voorrips et al, 1993). The PAR values used in this study were adopted from previous published studies on energy consumption (Calloway & Zanni, 1980; FAO/WHO/UNU, 1985; James & Schofield, 1990; Voorrips et al, 1993). It is important to bear in mind that the PAR values are not any exact values;

rather, they are mean estimations, often based on small samples, and generalisation of the values is therefore questionable (Durnin, 1996).

In the report "Energy and protein requirements" by the FAO/WHO/UNU (FAO/WHO/UNU, 1985), a PAL of 1.27 has been suggested as a minimum survival requirement, and of 1.55, as average PAL associated with a sedentary lifestyle. The PAL value of 1.27 was calculated with the assumption of 8 hours of sleep and 16 hours of activity at a PAL of 1.4. However, this is not the average activity pattern of nursing home patients, especially not in our study. The PAL of 1.27 as a minimum survival requirement therefore appears to fit more healthy, free-living persons, and not nursing home patients. Black et al (Black et al, 1996), has in a meta-analysis of DLW studies, suggest a minimum PAL of 1.2 for a sedentary (i.e. chair-bound or bedridden) lifestyle. This PAL value of 1.2 is drawn as a conclusion from four studies, but only seven out of the 80 participants whom this conclusion was based on were nonambulant elderly. Goldberg et al (Goldberg et al, 1991) suggest a minimum PAL of 1.35 as compatible with long-term weight maintenance in normal, healthy, free-living adults, but do not rule out that a PAL of 1.2 is possible in completely chair-bound or bedridden patients. A PAL of 1.5-1.8 has been suggested to be a sufficient level in the elderly and a PAL of 1.4 as the minimum acceptable maintenance level (Dupont et al, 1996). A sedentary lifestyle among nursing home patients is probably a major factor explaining the low PAL values the present study. However, PAL values <1.2 are quite possible to obtain. In an experimental DLW study, Goran et al (Goran et al, 1994) report a mean PAL of 1.17 during repeated measurements of five younger men (mean age 23 years) living under sedentary conditions.

Even though the mean PAL of 1.2 and the range of 1.01 to 1.40 in this study appear to be very low, it should not be concluded that energy requirements of geriatric patients should be at a PAL level of 1.2. The present study does not indicate whether the recorded energy expenditure level was sufficient for maintaining a sufficient level of physical activity, and consequently, muscle mass, for each patient, even though the BW of the patients did not change much during the study period of almost 6 months. Therefore, the reported findings cannot be used to determine whether the patients had adapted their physical activity to a lower energy intake/expenditure or whether the energy intake/expenditure was sufficient to support an optimal PAL. It is possible that institutionalised patients can adapt and maintain their energy balance at a suboptimal level. In an experimental study by Elmståhl et al (Elmståhl et al, 1987) of a changed meal environment and a changed mealtime serving system in a geriatric ward, the energy intake in 16 geriatric patients increased by 25% during a 4-month period. Even though the energy intake increased there were no changes in the participants' BW during the experiment period, indicating that the patients' physical activity also increased during the experiment. Patients' adaptation to a low level of TEE does not promote health in the longer term and gives no flexibility or space for any exercises or increased physical activity. On the contrary, this situation will discourage healthy muscle activity and may lead to a higher risk of amyotrophia and sarcopenia and in turn, a lower degree of physical activity which could have a

negative influence on the patients' health (Fiatarone Singh, 2001). This could create a vicious circle and once started, it will be difficult for the elderly to get out of it.

Total energy expenditure in geriatric patients is generally lower than in healthy younger people and this is especially true of patients with diseases that restrict the physical activity. Since we tested for metabolic thyroid and liver diseases, we could rule them out as sources of error. Only one patient had a diagnosed cancer. Even though the four patients with reported fever during the DLW measurement period had a significantly lower PAL than did the patients without fever, the TEE did not differ significantly between patients with and patients without a fever. The subjects in this study were nursing home patients, many of whom many had multiple diseases that could negatively affect physical activity. The low PAL in this study was seen especially in stroke patients and in patients with other diagnoses, whereas patients with dementia showed higher levels of physical activity (see Table 13). Only twelve of the 31 patients could move about independently and none of the patients took part in any regular physical training or rehabilitation. The nursing home environment itself may also have had a restricting influence on the residents' physical activity. Only one of the patients participated in the daily activities in the nursing home, besides the personal activities. Consequently, there seem to have been few opportunities for physical activity for the patients in this study.

The DLW method is at present the best method for measuring human TEE in field conditions. The error of the analytical precision of the method has been reported to be in the range of ±3-6% (Prentice, 1990; Schoeller & Hnilicka, 1996). In the present study, the measured TEE is a mean value of measurements during 3 weeks. Variation of physical activity and the variation in the DLW technique together with the uncertainty of PAL estimation, could possibly explain some of the variation of the used equations.

Equations using BW (Beaufrere et al, 2000), or body-weight and height (Dupont et al, 1996) have been suggested to provide reasonable estimates of BMR in the elderly. Out of the 13 tested equations in this study, the BMR predictive equations of Harris and Benedict (Harris & Benedict, 1919) are perhaps one of the most commonly used. Even though the original study by Harris and Benedict (series I) (Harris & Benedict, 1919) did not include many elderly subjects, Benedict later published other studies (series II) (Benedict, 1928), (Bangor series) (Benedict, 1935) that include elderly, but without changing the original equations published in 1919. During the past few decades, the Harris-Benedict equations have been criticised for providing unreliable results (Garrel et al, 1996; Roza & Shizgal, 1984). The predictive equation of Harris and Benedict (Harris & Benedict, 1919) accepts a difference of ±10% between the predictive and the measured value in normal subjects (Benedict, 1928). In our study, the Harris-Benedict equations, together with an estimated PAL value, underestimated DLW-measured TEE by a mean 12.7% and also underestimated TEE in all three subgroup analyses of sex, physical activity, and age. Similar underestimations were noted for equations E8 (Mifflin et al, 1990), E9

(Fredrix et al, 1990) and E13 (Lührmann et al, 2002). The pattern was similar in equation E3 (FAO/WHO/UNU, 1985), since even though the mean underestimation of TEE was 6.9% for all subjects, the equation especially underestimated TEE for men (-14.4%) and young subjects (-10.5%). In the equations E11 (Vinken et al, 1999) and E12 (Poehlman & Dvorak, 2000), the opposite was found. These two equations overestimated mean TEE in all patients by 12.5% and 19.6%, respectively, and in some subgroup analyses including men, low PAL, and elderly patients, there was an overestimation of >20%. The equations E11 and E12 predict TEE but unlike the rest of the equations used in this study, they do not predict BMR and it seems that these two equations are based on subjects with a higher PAL than seen in the patients participating in our study.

Schofield et al (Schofield, 1985a) reviewed the literature on BMR/RMR and provided a series of predictive equations (Schofield, 1985b). These formed the basis for the equations presented in the FAO/WHO/UNU report (FAO/WHO/UNU, 1985). Altogether, five equations (E2-E6) in the present study are presented by, or based on data from, Schofield's, and all but one (E3) of these predict TEE within the ±10% range. A meta-analysis by Elia et al (Elia et al, 2000) of DLW studies in healthy, free-living elderly compared measured BMR with estimated BMR using Schofield's BMR equation with BW (E4) (Schofield, 1985b) as a predictor. In 88 women (mean age 68 years), mean measured BMR was 5.53 MJ and mean predicted BMR 5.47 MJ; corresponding figures in 98 men (mean age 71 years) were 6.40 MJ and 6.23 MJ, respectively. In our study, equation (E4) was among the equations that could predict TEE within a range of ±10%.

Of the 13 tested equations in this study, seven (E2, E4, E5, E6, E7, E10, E13) were able to predict TEE within a range of ±10% and four of these (E2, E5, E7, E10) to predict TEE within a range of ±5%. Equation E5 (Schofield, 1985b), however, had a slightly higher RMSE and a slightly poorer result in the subgroup analysis, especially for men, younger subjects, and patients with a high PAL. The best predictive equation in the present study was E10 (Westerterp et al, 1995a), with a 1.4% mean overestimation of TEE and the lowest RMSE, of 0.71 MJ. The two second best equations were E2 (FAO/WHO/UNU, 1985) using both BW and height, and E7 (Owen et al, 1986; Owen et al, 1987) using only BW.

Objections against using height in BMR/TEE predictive equations could include a reduced compliance among geriatric patients, technical difficulties, and bias towards vertebral compression fractures (Eveleth et al, 1998). Surprisingly, however, three out of the seven best predictive equations, and two out of the three best equations, in this study use both BW and height in the BMR equation.

Even if a predictive value on energy requirement is possible to obtain through a combined estimation of BMR and PAL, individual adjustments will still have to me made in clinical use based upon the individuals hunger and BW changes.

Many studies have indicated that FFM has a high correlation with TEE (Cunningham, 1991), at least in healthy and active, free-living younger adults (Westerterp et al, 1992). In this study, the highest correlation's was found in FFM and TBW measured by DLW, but the correlations with the BIA estimations were poorer. In a comparison of the body composition measurements with BIA and DLW, the BIA underestimated both FFM and TBW by 10%, while overestimating FM. When we compare our results with those in Rothenberg et al's study on 91-96-years-olds (Rothenberg et al, 2000), the results on body composition and TEE/PAL are similar; however, when it comes to comparing BIA with DLW, the study by Rothenberg et al presents contradictory results to ours.

The FAO/WHO/UNU recommendations were published in 1985 (FAO/WHO/UNU, 1985), and were based on a conference held in 1981. During the 20 years since 1981, many studies have been published on energy expenditure in humans using the DLW technique. The results of our and other studies and the results from last few decades of DLW work suggest a need to re-evaluate energy requirement recommendations and the prediction of energy needs for the elderly in general, and for geriatric patients in particular.

Conclusions

We identified 13 equations to predict BMR/TEE in geriatric patients and tested them against TEE measured by DLW in combination with an estimation of PAL in 31 geriatric patients. The best predictive equation (E10) in this study was the one by Westerterp et al (Westerterp et al, 1995a). However, the equation by Westerterp et al may be too complex to use in a clinical setting. A somewhat easier equation to use is the one by FAO/WHO/UNU (FAO/WHO/UNU, 1985) based on BW and height (E2). If only BW is to be used, the equation (E7) by Owen et al (Owen et al, 1986; Owen et al, 1987) is the equation to be recommended.

Acknowledgements

We are grateful to Dr. Klaas Westerterp of Maastricht University, The Netherlands, for help with the DLW calculation. The study was supported by grants from: the Department of Clinical Nutrition, Lund University Hospital, Lund, Sweden; Lund University, Lund, Sweden; the Municipality of Malmö, Malmö Sweden; Nutricia Nordica AB, Stockholm, Sweden; Påhlsson's Foundation, Malmö, Sweden; the Swedish Foundation for Health Care Sciences and Allergy Research (grant No. V97-234 and V99-090), Stockholm, Sweden; the Swedish Nutrition Foundation, Lund, Sweden; the Swedish Society of Nursing, Stockholm, Sweden; the Gun and Bertil Stohnes Foundation, Stockholm, Sweden; the Family Janne Elqvist Foundation, Nybro, Sweden; Loo and Hans Ostermans Foundation for Geriatric Research, Stockholm, Sweden.

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V

Dietary Intake and Mealtime Habits in Geriatric Patients

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Abstract

Background and aims: Providing patients with a dietary intake that meets individual needs is an essential task of nutritional care. This study aims to describe the dietary intake and mealtime habits in relation to requirements among geriatric patients and to explore differences in dietary intake over a 4-year period.

Methods: A 7-day dietary intake was recorded for 220 geriatric patients, 164 women and 56 men with a mean age of 86 years from ten sheltered housing, using an clinically adapted dietary record routine.

Results: The mean daily energy intake was 6.4 MJ in women and 7.4 MJ in men. Sixty-two per cent of the patients had an energy intake below the calculated energy requirements. Almost the entire energy intake took place within 9 hours during daytime. The variation in energy intake between the different wards exceeded the variation between assessments in 1995, 1996 and 1998-1999.

Conclusions: The nursing staff seemed unable to ensure that the patients' individual dietary needs were met. A change is needed in strategy to prevent malnutrition in the elderly. The low intake of several vitamins and minerals shows that there is a need for a full daily dietary supplementation to be given to all geriatric patients.

Key words: Dietary intake, fluid intake, geriatric patients, malnutrition, mealtime habits, nursing homes.

Introduction

Malnutrition in geriatric patients is an important clinical and public health problem. One major factor contributing to its prevalence appears to be the failure of health care professionals to recognise its signs and identify patients with malnutrition or at risk of becoming malnourished (1-3). Several studies have shown that patients with malnutrition are not correctly diag-nosed (1-3) and that documentation in medical and nursing records is insufficient (2, 4, 5). A high rate of malnutrition in elderly patients has been noted in various clinical set-tings by many investigators over the last few decades (6-8). A summary by the Swedish National Board of Health and Welfare of 25 published Swedish studies during the past 20 years comprising a total of 5120 patients in different types of wards, showed a mean malnutrition prevalence of 28% (8). No major improvements were noted in the prevalence of malnutrition during the past decades, but different methods were used to assess malnutrition (8). Malnutrition is associated with complications such as reduced body weight (BW), loss of appetite, decreased physical ability (9), increased incidence of decubi-tus (10, 11), increased risk of infections (12, 13), prolonged hospitalisation (14, 15) and a high mortality rate (15-17).

Various methods of assessing dietary intake can be used to identify patients at risk of becoming malnourished (18, 19). Retrospective methods include dietary history, food frequency questionnaires and 24-hour recall, whereas prospective methods include the use of dietary records and duplicate meals. Assessment of dietary intake of hospitalised patients can either be self-administered by the patient's (20) or observed by the staff (21). Sometimes the observational methods are not designed to cover the complete 24-hour day but only to assess the intake at major meals (22). The method of choice for collecting food consumption data and monitoring nutritional status in geriatric patients is the staff-administered dietary record (18), because the findings are not influenced by various kinds of illness and levels of cognitive impairment, which are common in this population. Owing to intra- and interpersonal variation, food and fluid intake must be recorded for several days before the patients' intakes can be classified (18, 23).

Dietary intake is usually described as a mean daily intake of macronutrients (fats, carbohydrates and proteins) and micronutrients (vitamins and minerals) (24), while the mealtime habits are not usually reported. Little has yet been published about eating periodicity in geriatric patients, that is, about the frequency of eating events, or eating episodes, of various food compositions, the diurnal variations of eating events (meals and snacks) across the 24-hour day, the role of eating events as major contributors of energy and nutrients, and/or the relationship between timing or frequency of eating and nutritional status (25). The Food-based Classification of Eating Episodes (FBCE) is a tool developed to categorise eating events and can be used to objectively classify the diurnal variations of eating (25).

Providing patients with a dietary intake that meets individual needs is an essential task for all health care professionals in nutritional care. It is especially important in the care of the frail elderly living in sheltered housing such as nursing homes and community resident homes. Helping patients with eating and drinking adequately is one of the fundamental basic principles of nursing care (26). An adequate nutritional status is also the key point to successful rehabilitation of the patients.

During the past years in Sweden the public debate about malnutrition and care of the elderly living in sheltered housing has been intense, fuelled by several reports, among them a report by the Swedish National Board of Health and Welfare (8). However, to date it has not been investigated whether this debate has had a direct influence on the nutritional care of the elderly and whether it has led to an increased dietary intake in geriatric patients.

Aims

The aims of this study were to describe the dietary intake and mealtime habits in relation to dietary requirements among geriatric patients and to explore differences in dietary intake in geriatric patients over a 4-year period.

Material and methods

Population and subjects

The study population were recruited from ten sheltered housing units, seven nursing homes and three community resident homes, in a Swedish municipality during 1995, 1996 and 1998-1999. Different wards and patients were observed each year. Inclusion criteria were nursing home/community resident home residence and the ability to orally ingest food and fluids. Exclusion criteria were parenteral or enteral nutrition, acute illness, or terminal conditions, where death was expected within a few weeks.

Out of 250 patients, 220 met the inclusion criteria and agreed to participate in the study. Thus, the study group consisted of 220 patients (164 women and 56 men) with a mean age of 86 years (SD ±7.7 years; range 55-103 years) (see Table 1). Out of the total number of patients the participation rate for 1995 was 91% (n=61); for 1996 79% (n=81); and 1998-1999 96% (n=78). In 30 patients (19 women and 11) men with a mean age of 87 years (SD ± 8.1 years; range 87-102 years) data were not obtained, due to eight patients died before any diet recording was done, three patients died during the recording, two patients was discharged from the ward and 17 patients were excluded due to acute illness.

Dietary and fluid intake

The record form used in the study is a newly developed estimated dietary record form for use in clinical settings and is designed to be as self-explanatory to nursing staff as possible. It consists of two A4 pages. The front page is for individual dietary recording over a 24-hour period and the back page gives information about the energy content of some 100 food items that are common in hospital settings (27). The reproducibility (27) and validity (28) of the dietary record routine have been described previously.

Before the start of the study the nursing staff attended a 1-hour (1995 and 1998-1999) or a 2-hour (1996) training session on taking dietary records. The training consisted of oral and written information on the dietary record routine and practical training in assessing portion sizes using both actual dishes (all occasions) and photos of different dishes (1996 and 1998-1999). During the study period, the nursing staff was provided with written information on the recommended portions (all occasions) and with photos of different portion sizes (1996 and 1998-1999).

The recording was done in May 1995 (n=61), between March and May (n=48) in 1996, between November and December (n=33) in 1996, and between December 1998 and April 1999 (n=78). No recording was done during any major holidays. The recording in 1995 was done during 9 days, but in this study only the first 7 days,

Table 1. *Mean age and body weight, SD and range, type of diet and intake of dietary supplements at some point during the dietary registration in women and men for the different study years. P-values with in the sexes using Kruskal-Wallis test are given as letters: b=P<0.01, and c=P<0.001. P-values between the sexes using Mann-Whitneys U-test (women n=164 and men n=56) are given as: **=P<0.01, and ***=P<0.001.*

	Women				**Men**				**All**
	1995 *n*=43	1996 *n*=56	1998-99 *n*=65	All women *n*=164	1995 *n*=18	1996 *n*=25	1998-99 *n*=13	All men *n*=56	1995-1999 *n*=220
Age (years)	87 ±6.6	87 ±7.8	86 ±6.9	87 ±7.1	83 ±9.9	82 ±7.1	83 ±8.8	82 ±8.4	86 ±7.7 ***
	(69-103)	(58-97)	(68-98)	(58-103)	(55-95)	(65-94)	(58-91)	(55-95)	(55-103)
Body weight (kg)	50.9 ±10.3	52.6 ±9.4	57.2 ±12.2	54.0 ±11.1 ***b***	67.9 ±14.0	66.9 ±11.7	71.8 ±12.0	68.4 ±12.5	57.7 ±13.0 ***
	(37.0-87.3)	(35.5-76.1)	(31.5-102.0)	(31.5-102.0)	(45.0-102.0)	(43.0-97.5)	(51.5-96.0)	(43.0-102.0)	(31.5-102.0)
Diets									
regular	49%	77%	95%	77% ***c***	55%	64%	92%	68%	74%
pureed	44%	23%	5%	21%	39%	36%	8%	30%	24%
liquid	7%	0%	0%	2%	6%	0%	0%	2%	2%
Dietary supplements	28%	14%	6%	15% ***b***	17%	12%	15%	14%	15%

5 weekdays and 2 weekend days, are used and reported. In 1996 the recording was done in two consecutive 7-day periods, with a median time gap of 21 days between the periods, but in this study only the results from the first 7 days period are used and reported. In 1998-1999 the recording was done during 7 consecutive days. In three patients the dietary recording only covered 6 days (4-5 weekdays and 1-2 weekend days) and in one patient the recording was of only 5 days (3 weekdays and 2 weekend days). These results are included in the study.

Standardised portion sizes using the quartile method (0, 1/4, 2/4, 3/4, 1/1) were used for lunch and supper. Breakfast, snacks and beverages were assessed separately using household measuring devices. In 1995 and 1996 the food was prepared by the hospital kitchen staff and served by the nursing staff. In 1998-1999 the nursing staff served all meals and prepared breakfast and supper. As for lunch, in two out of three community resident homes the meat/fish and sauce were delivered by caterers, while potatoes/rice/pasta, vegetables and dessert were prepared by the nursing staff. In the third community resident home the nursing staff prepared the lunch on 4 days a week, while on the other 3 days the lunch was delivered by a restaurant. Diets were classified as “regular”, “pureed” or “liquid”.

The recipes from all the different kitchens were collected and used to calculate the energy and nutrient content of each meal. Swedish standards for the mean weight and/or volume of different food items and portion sizes were used for snacks and beverages (29, 30). The utensils used on the wards were calibrated by volume. Nutrient intake was calculated using the same nutrient computer software program (AIVO Kostplan 2.20, Stockholm, Sweden 2000 and Food Composition Table from Swedish PC-kost, June 2000, National Food Administration, Uppsala, Sweden) for all samples. Dietary records were coded by one of the investigators and then checked independently by another in order to rule out coding errors.

Fluid intake from all consumed beverages was calculated. Water intake was calculated, using food composition tables, from the combined intake of fluids and from food items.

Information on medication was retrieved from medical and nursing documentation. Vitamins and minerals given as medication were not added to the estimated dietary intake of nutrients.

Mealtime habits

The time of each meal and between-meal snack was registered in the dietary records. The overnight time period during which the resident was not served any food or beverages was calculated according to the notes from the dietary records. The 24-hour day was divided into seven periods: breakfast (about 07:00-09:00), snacks in the morning (about 09:00-12:00), lunch (about 12:00-13:00), snacks in the afternoon (about 13:00-16:00), supper meal (about 16:00-18:00), snacks in the evening

(about 18:00-21:00), and snacks during the night (21:00-07:00). The expression "daytime" is used for the period from 07:00 to 18:00. The expression "major meals" includes breakfast, lunch and supper, but no between-meal snacks.

The mealtime habits have been categorised using the FBCE tool to describe the dietary intake during each of the seven time periods during the 24-hour day (25). A description of the FBCE tool is given in Appendix 1.

Dietary and energy requirements

Dietary requirements have been calculated based on the Nordic Nutrition Recommendations 1996 (NNR96) (31) for recommended daily intake (RDI). Since the NNR96 have been compiled for healthy, free-living people, some adjustments had to be made to the recommended intake of macronutrients. Energy requirements have been calculated based on Swedish recommendations for hospital nutrition (32, 33) using the equation of 33 kcal/kg BW minus 10% for age (since elderly people are less physically active). Protein requirements have been calculated based on the assumption that 15% of the mean total dietary energy should come from protein and that the corresponding figures for fat and carbohydrates should be 35% and 50%, respectively (32). Dietary fibre requirements have been calculated to be 10 g/1000 kcal (34). Vitamin A is given as retinol equivalents calculated from the intake of retinol plus one-sixth of the β-carotene intake. Niacin is given as niacin equivalents. The term "minimum safety level" is the lower limit of intake recommended in the NNR96 since a "prolonged intake below these levels may induce a risk of deficiency" (31).

Ethics

Each patient and/or a close relative gave an oral informed consent to the patient's participation in the study. The data collected in 1996 was a part of a study approved by the Local Ethical Committee at Lund University, Lund, Sweden.

Statistics

Statistical analyses were performed using SPSS for Windows (10th ed., SPSS Inc, Chicago, IL, USA, 1999). Values are expressed as means and standard deviations (SD). Results were considered to be statistically significant if P-values were <0.05. Non-parametric methods were used for the analyses as the samples were small and not normally distributed (35). Differences in the dietary intake between women and men and between patients with an EI above and patients with an EI below calculated energy requirements were examined using the two-tailed Mann-Whitney U-test. Differences between the different recording years (1995, 1996 and 1998-1999), the different wards and age groups (<70, 70-79, 80-89 and >90 years of age), quartiles of overnight period without food, and quartiles of the number of meals, were examined using the Kruskal-Wallis test.

Results

The mean daily EI was 6.44 MJ (SD ±1.44 MJ; range 1.44-11.93 MJ) in women (see Table 2) and 7.38 MJ (SD ±1.53; range 4.52-12.56 MJ) in men (see Table 3). Data for specific nutrients are given in Tables 2 and 3. Mean daily EI/kg BW was 29.4 kcal (SD ±7.7 kcal; range 8.6-50.5 kcal) in women (see Table 2) and 26.4 kcal (SD ±6.6 kcal; range 16.2-54.1 kcal) in men (see Table 3). A comparison between EI values over the years 1995-1999 showed that there was an increase in intake for women in crude values; however, when we converted this to EI/kg BW we found that the EI was highest in 1996 (see Table 2). In men the EI in crude values was lowest in 1995; however, when we converted this to EI/kg BW we found that the EI was the lowest in 1998-1999 (see Table 3). There was a large difference in mean daily EI/kg BW between the different wards ranging from 24.3 kcal to 36.2 kcal and the proportion of patients who had a sufficient EI, according to calculated energy requirements, ranged from 19-65%. Out of the 220 participants 62% had an insufficient EI, according to calculated energy requirements. Altogether 57% of the women and 77% of the men had an EI below calculated energy requirements (see Table 4). The proportions of patients who had an inappropriate intake of the nutrients varied from 2% to 100% (see Table 4). Energy intake/kg BW, fluid intake/kg BW, water intake/kg BW and percentage of patients with an insufficient EI did not differ significantly between age groups and types of diet.

As previously mentioned, the 24-hour day was divided into seven time periods and the mean number of meals/day (intake of food and/or fluids in any of the periods) was 4.7 (SD ±0.7; range 2.4-6.9). The mean values between the different wards ranged from 4.4 to 5.7 meals/day. There was a significant difference ($P=0.02$) between patients with an EI above and patients with an EI below the calculated energy requirements. Patients with an EI above calculated energy requirements had a mean value of 4.9 meals/day, while the corresponding value for patients with an EI below the calculated energy requirements was 4.6 meals/day. Patients with many meals/day had a higher EI than did patients with fewer meals/day. The quartile of patients (n=59) with the highest number of meals/day (5.0-6.9) had a mean daily EI of 1803 kcal (SD ±351 kcal; range 1156-2852 kcal). The corresponding value in the quartile (n=59) with the fewest meals/day (2.4-4.1) was 1512 kcal (SD ±390 kcal; range 343-3001 kcal) ($P<0.001$). The variation in mean EI/day, mean fluid intake/day and mean water intake/day between the days of the week appear to be random. There was a slight increase in EI during the weekend days compared with weekdays; however, this was not statistically significant.

The mean daily fluid intake was 1163 mL (SD ±299 mL; range 414-2236 mL) in women and 1266 mL (SD ±286 mL; range 791-1934 mL) in men (see Table 5). The mean daily fluid intake/kg BW was 22.3 mL (SD ±7.4 mL; range 9.9-56.6 mL) in women and 19.1 mL (SD ±5.7; range 9.3-38.2 mL) in men (see Table 5). The range of mean values of fluid intake/kg BW between the different wards was 16.9-27.1 mL.

Table 2. *Mean dietary intake, SD and range, energy intake (EI), fluid intake (FI) and water intake (WI) in women. P-values using Kruskal Wallis test on differences between the years are given as: *=P<0.05, **=P<0.01, ***=P<0.001.*

	1995 (*n*=43)	**1996** (n=56)	**1998-1999** (*n*=65)		**All women** (*n*=164)
Energy (MJ)	5.69 ±1.32 (1.44-8.81)	6.69 ±1.27 (4.30-9.20)	6.72 ±1.49 (3.67-11.93)	***	6.44 ±1.44 (1.44-11.93)
Protein (g)	54.2 ±15.5 (15.4-87.1)	59.1 ±14.6 (29.6-91.2)	55.3 ±12.2 (34.2-84.9)		56.3 ±14.0 (15.4-91.2)
Fat (g)	42.9 ±12.0 (5.2-67.5)	54.1 ±13.5 (25.6-83.9)	62.6 ±16.3 (27.8-103.0)	***	54.5 ±16.3 (5.2-103.0)
Carbohydrates (g)	187.0 ±42.9 (58.0-316.0)	214.2 ±41.2 (110.0-296.0)	203.4 ±56.1 (120.0-427.0)	**	202.8 ±48.9 (58.0-427.0)
Alcohol (g)	0.4 ±1.2 (0.0-5.4)	1.8 ±3.0 (0.0-12.8)	0.4 ±1.2 (0.0-5.7)	**	0.9 ±2.1 (0.0-12.8)
Dietary fibre (g)	9.7 ±3.4 (0.5-16.2)	11.8 ±2.9 (5.7-19.5)	11.1 ±3.2 (2.6-21.7)	**	11.0 ±3.2 (0.5-21.7)
Vitamin A (µg)	654.5 ±343.7 (128.2-1791.7)	821.3 ±484.5 (272.0-2740.5)	747.2 ±277.1 (317.3-1664.0)	*	748.2 ±385.6 (128.2-2740.5)
Vitamin D (µg)	2.5 ±1.3 (0.7-6.9)	2.6 ±1.2 (0.4-6.2)	3.6 ±1.3 (1.4-6.5)	***	2.9 ±1.4 (0.4-6.9)
Vitamin E (mg)	5.0 ±3.3 (1.5-22.2)	4.6 ±1.6 (1.1-9.0)	5.9 ±1.9 (2.5-10.9)	***	5.2 ±2.3 (1.1-22.2)
Thiamin (mg)	1.0 ±0.3 (0.3-1.9)	1.1 ±0.3 (0.5-2.2)	1.0 ±0.2 (0.6-1.4)		1.0 ±0.3 (0.3-2.2)
Riboflavin (mg)	1.4 ±0.4 (0.4-2.7)	1.5 ±0.4 (0.8-2.6)	1.3 ±0.3 (0.7-2.5)	*	1.4 ±0.4 (0.4-2.7)
Niacin (mg)	20.5 ±6.1 (7.0-33.0)	22.5 ±6.2 (10.1-37.4)	20.7 ±4.4 (11.0-30.5)		21.2 ±5.5 (7.0-37.4)
Vitamin B6 (mg)	1.2 ±0.4 (0.5-2.5)	1.3 ±0.3 (0.7-2.6)	1.1 ±0.2 (0.6-1.7)	*	1.2 ±0.3 (0.5-2.6)
Folate (µg)	136.6 ±52.8 (55.4-332.0)	155.7 ±58.0 (79.2-353.0)	157.6 ±41.1 (81.1-284.0)	**	151.5 ±51.0 (55.4-353.0)
Vitamin B12 (µg)	3.6 ±1.2 (1.0-6.3)	4.2 ±1.6 (2.0-11.8)	3.7 ±1.0 (1.8-6.5)		3.8 ±1.3 (1.0-11.8)
Vitamin C (mg)	72.9 ±39.5 (29.8-185.0)	82.2 ±52.1 (32.3-329.0)	69.0 ±42.2 (19.7-186.0)		74.6 ±45.2 (19.7-329.0)
Calcium (mg)	958.8 ±316.2 (323.0-1828.0)	1016.5 ±244.2 (569.0-1546.0)	880.9 ±242.6 (427.0-1724.0)	**	947.6 ±269.1 (323.0-1828.0)
Iron (mg)	5.9 ±2.4 (2.6-16.7)	6.3 ±1.8 (3.4-12.1)	6.8 ±2.4 (3.4-13.2)		6.4 ±2.3 (2.6-16.7)
Zinc (mg)	7.2 ±2.2 (2.5-12.6)	8.4 ±2.1 (3.4-14.7)	7.9 ±1.8 (4.4-12.2)	*	7.9 ±2.1 (2.5-14.7)
Selenium (µg)	24.9 ±9.0 (2.0-54.5)	25.4 ±9.1 (11.7-56,2)	25.2 ±6.5 (13.2-39.5)		25.2 ±8.1 (2.0-56,2)
Sufficient EI (%)	26	57	43	**	43
EI/kg BW (kcal)	27.3 ±7.1 (8.6-49.3)	31.3 ±7.7 (18.0-49.4)	29.1 ±7.9 (12.3-50.5)	*	29.4 ±7.7 (8.6-50.5)
FI/kg BW (mL)	24.1 ±9.1 (10.4-56.6)	24.4 ±6.8 (14.4-48.7)	19.4 ±5.4 (9.9-34.6)	***	22.3 ±7.4 (9.9-56.6)
WI/kg BW (mL)	31.9 ±10.1 (8.6-73.5)	33.2 ±7.8 (18.1-59.0)	27.1 ±6.6 (14.1-42.8)	***	30.4 ±8.5 (8.6-73.5)

Table 3. ***Mean dietary intake, SD and range, energy intake (EI), fluid intake (FI) and water intake*** *(WI) in men. P-values using Kruskal Wallis test on differences between the years are given as: *=P<0.05, **=P<0.01, ***=P<0.001.*

	1995 (*n*=18)	**1996** (*n*=25)	**1998-1999** (*n*=13)		**All men** (*n*=56)
Energy (MJ)	6.83 ±0.91	7.88 ±1.32	7.17 ±2.24	*	7.38 ±1.53
	(5.61-8.35)	(4.52-9.81)	(4.63-12.56)		(4.52-12.56)
Protein (g)	62.8 ±10.4	71.0 ±14.5	58.1 ±18.9	*	65.4 ±15.3
	(48.4-79.8)	(36.8-89.7)	(39.8-103.0)		(36.8-103.0)
Fat (g)	50.4 ±9.2	63.4 ±12.6	63.8 ±21.8	**	59.3 ±15.4
	(33.3-65.0)	(38.5-84.1)	(38.1-115.0)		(33.3-115.0)
Carbohydrates (g)	227.5 ±30.7	247.6 ±41.6	219.9 ±72.0		234.7 ±48.2
	(169.0-276.0)	(145.0-320.0)	(141.0-385.0)		(141.0-385.0)
Alcohol (g)	3.1 ±3.9	4.3 ±4.1	3.0 ±4.5		3.6 ±4.1
	(0.0-12.5)	(0.0-12.2)	(0.0-15.1)		(0.0-15.1)
Dietary fibre (g)	11.8 ±2.6	15.1 ±3.9	12.8 ±5.0	*	13.5 ±4.0
	(5.1-16.9)	(5.9-22.5)	(5.8-20.6)		(5.1-22.5)
Vitamin A (µg)	767.3 ±472.4	857.2 ±500.7	845.0 ±355.7		825.4 ±465.1
	(326.2-2332.8)	(274.5-2712.7)	(484.5-1531.8)		(231.5-2780.8)
Vitamin D (µg)	2.9 ±1.0	3.3 ±1.0	3.6 ±1.4		3.2 ±1.1
	(1.6-6.0)	(1.6-5.3)	(1.9-6.3)		(1.6-6.3)
Vitamin E (mg)	5.7 ±3.4	5.8 ±1.6	6.2 ±2.3		5.9 ±2.4
	(3.3-18.2)	(3.2-11.2)	(3.9-10.7)		(3.2-18.2)
Thiamin (mg)	1.2 ±0.2	1.4 ±0.3	1.2 ±0.6	*	1.3 ±0.4
	(0.9-1.8)	(2.6-8.9)	(0.7-2.8)		(0.6-2.8)
Riboflavin (mg)	1.5 ±0.3	1.7 ±0.4	1.5 ±0.7	*	1.6 ±0.5
	(0.8-2.3)	(0.7-2.8)	(0.8-3.6)		(0.7-3.6)
Niacin (mg)	25.1 ±3.8	28.2 ±6.1	23.4 ±9.2	*	26.1 ±6.6
	(18.1-32.2)	(12.2-37.9)	(14.0-48.5)		(12.2-48.5)
Vitamin B6 (mg)	1.5 ±0.3	1.7 ±0.4	1.3 ±0.3	**	1.5 ±0.4
	(0.9-2.3)	(0.6-2.7)	(0.9-2.0)		(0.6-2.7)
Folate (µg)	159.0 ±45.1	183.4 ±64.8	174.9 ±59.2		173.6 ±57.8
	(110.0-288.0)	(93.8-356.0)	(104.0-330.0)		(93.8-356.0)
Vitamin B12 (µg)	3.9 ±1.0	4.8 ±1.6	3.6 ±1.2	*	4.3 ±1.4
	(2.2-6.8)	(1.9-9.9)	(2.2-6.2)		(1.9-9.9)
Vitamin C (mg)	72.8 ±26.7	86.2 ±56.2	79.5 ±47.7		80.3 ±46.2
	(42.0-136.0)	(14.3-250.0)	(28.4-203.0)		(14.3-250.0)
Calcium (mg)	979.7 ±251.9	1110.3 ±252.5	879.5 ±276.6	*	1014.8 ±269.7
	(495.0-1380.0)	(563.0-1564.0)	(558.0-1511.0)		(495.0-1564.0)
Iron (mg)	7.1 ±2.0	7.7 ±1.9	7.7 ±3.4		7.5 ±2.3
	(5.0-13.0)	(3.7-12.4)	(4.0-14.3)		(3.7-14.3)
Zinc (mg)	8.2 ±1.7	10.4 ±2.2	8.3 ±2.7	*	9.2 ±2.4
	(5.8-11.5)	(4.8-14.0)	(5.6-13.9)		(4.8-14.0)
Selenium (µg)	30.5 ±6.6	29.6 ±9.2	25.8 ±9.0		29.0 ±8.5
	19.8-43.7)	(8.8-57.2)	(14.6-45.6)		(8.8-57.2)
Sufficient EI (%)	22	32	8		23
EI/kg BW (kcal)	24.8 ±4.7	28.9 ±7.2	23.9 ±6.4	*	26.4 ±6.6
	(16.7-32.1)	(17.0-54.1)	(16.2-41.1)		(16.2-54.1)
FI/kg BW (mL)	19.8 ±5.5	19.5 ±6.0	17.5 ±5.3		19.1 ±5.7
	(12.2-29.4)	(11.4-38.2)	(9.3-26.1)		(9.3-38.2)
WI/kg BW (mL)	28.3 ±6.1	30.2 ±8.8	24.3 ±4.9		28.2 ±7.5
	(18.0-42.4)	(18.2-58.8)	(17.9-31.5)		(17.9-58.8)

Table 4. *Dietary intake and Nordic Nutrition Recommendations (NNR96) for recommended dietary intake (RDI) levels in women and men. Values are given as mean daily intake, SD (±) and range. Values given in brackets in the columns with RDI correspond to minimum safety-level.*

	Women (*n*=164)			**Men** (*n*=56)		
	Dietary intake	RDI for women >75 years and minimum safety-level	Below RDI and minimum safety-level (%)	Dietary intake	RDI for men >75 years and minimum safety-level	Below RDI and minimum safety-level (%)
Energy (MJ)	6.44 ±1.44 (1.44-11.93)	6.71[1]	57	7.38 ±1.53 (4.52-12.56)	8.50[1]	77
Protein (g)	56.3 ±14.0 (15.4-91.2)	60	66	65.4 ±15.3 (36.8-103.0)	76	71
Fat (g)	54.5 ±16.3 (5.2-103.0)	62	71	59.3 ±15.4 (33.3-115.0)	79	89
Carbohydrates (g)	202.8 ±48.9 (58.0-427.0)	200	53	234.7 ±48.2 (141.0-385.0)	254	61
Alcohol (g)	0.9 ±2.1 (0.0-12.8)	-		3.6 ±4.1 (0.0-15.1)	-	
Dietary fibre (g)	11.0 ±3.2 (0.5-21.7)	16	90	13.5 ±4.0 (5.1-22.5)	20	93
Vitamin A (µg)	748.2 ±385.6 (128.2-2740.5)	800.0 (600.0)	57 (35)	825.4 ±465.1 (231.5-2780.8)	900.0 (600.0)	68 (21)
Vitamin D (µg)	2.9 ±1.4 (0.4-6.9)	10.0 (2.5)	100 (41)	3.2 ±1.1 (1.6-6.3)	10.0 (2.5)	100 (23)
Vitamin E (mg)	5.2 ±2.3 (1.1-22.2)	8.0 (3.0)	90 (10)	5.9 ±2.4 (3.2-18.2)	10.0 (4.0)	91 (11)
Thiamine (mg)	1.0 ±0.3 (0.3-2.2)	1.0 (0.5)	43 (1)	1.3 ±0.4 (0.6-2.8)	1.1 (0.6)	34 (2)
Riboflavin (mg)	1.4 ±0.4 (0.4-2.7)	1.2 (0.8)	27 (2)	1.6 ±0.5 (0.7-3.6)	1.3 (0.8)	23 (4)
Niacin (mg)	21.2 ±5.5 (7.0-37.4)	13.0 (9.0)	4 (1)	26.1 ±6.6 (12.2-48.5)	15.0 (11)	4 (0)
Vitamin B6 (mg)	1.2 ±0.3 (0.5-2.6)	1.1 (0.9)	35 (10)	1.5 ±0.4 (0.6-2.7)	1.2 (1.0)	14 (11)
Folate (µg)	151.5 ±51.0 (55.4-353.0)	300.0 (100)	98 (11)	173.6 ±57.8 (93.8-356.0)	300.0 (100)	95 (2)
Vitamin B12 (µg)	3.8 ±1.3 (1.0-11.8)	2.0 (1.0)	4 (0)	4.3 ±1.4 (1.9-9.9)	2.0 (1.0)	2 (0)
Vitamin C (mg)	74.6 ±45.2 (19.7-329.0)	60.0 (10.0)	49 (0)	80.3 ±46.2 (14.3-250.0)	60.0 (10.0)	38 (0)
Calcium (mg)	947.6 ±269.1 (323.0-1828.0)	800.0 (400.0)	33 (1)	1014.8 ±269.7 (495.0-1564.0)	800.0 (400.0)	23 (0)
Iron (mg)	6.4 ±2.3 (2.6-16.7)	10.0 -	94 -	7.5 ±2.3 (3.7-14.3)	10.0 (7.0)	89 (41)
Zinc (mg)	7.9 ±2.1 (2.5-14.7)	7.0 (4.0)	33 (2)	9.2 ±2.4 (4.8-14.0)	9.0 (5.0)	45 (2)
Selenium (µg)	25.2 ±8.1 (2.0-56.2)	40.0 (20.0)	96 (23)	29.0 ±8.5 (8.8-57.2)	50.0 (20.0)	98 (13)

[1] *Energy requirements were calculated as 33 kcal/kg BW minus 10% for elderly people with a reduced physical activity. Conversions from kcal to MJ were done by multiplying the kcal value by 0.004184. The given value is mean value for the women and men separately and corresponds to an estimated individual dietary recommendation and not to NNR96.*

Table 5. *Energy intake (EI), fluid intake (FI), and water intake (WI) calculated from diets and during different time periods. Daytime was defined as 07:00 to 18:00. Values are given as mean daily intake, SD (±), and range. P-values using Mann Whitneys U-test are given as *=P<0.05, **=P<0.01, ***=P<0.001.*

	Women (*n*=164)	**Men** (*n*=56)		**All** (*n*=220)
EI (kcal)	1540 ±343 (343-2852)	1759 ±369 (1080-3001)	***	1596 ±362 (343-3001)
EI/kg BW (kcal)	29.4 ±7.7 (8.6-50.5)	26.4 ±6.6 (16.2-54.1)	**	28.6 ±7.5 (8.6-54.1)
EI during daytime (%)	97 ±4 (74-100)	97 ±4 (83-100)		97 ±4 (74-100)
EI during the evening and at night (%)	3 ±4 (0-26)	3 ±4 (0-17)		3 ±4 (0-26)
EI from major meals (%)	87 ±7 (62-100)	86 ±5 (70-95)		87 ±6 (62-100)
EI from between-meal snacks (%)	13 ±7 (0-38)	14 ±5 (5-30)		13 ±6 (0-38)
FI (mL)	1163 ±299 (414-2236)	1266 ±286 (791-1934)	*	1189 ±298 (414-2236)
FI/kg BW (mL)	22.3 ±7.4 (9.9-56.6)	19.1 ±5.7 (9.3-38.2)	**	21.5 ±7.1 (9.3-56.6)
FI during daytime (%)	93 ±7 (72-100)	92 ±7 (68-100)		93 ±7 (68-100)
FI during the evening and at night (%)	7 ±7 (0-28)	8 ±7 (0-32)		7 ±7 (0-32)
FI from major meals (%)	74 ±10 (39-94)	73 ±10 (43-91)		74 ±10 (39-94)
FI from between-meal snacks (%)	26 ±10 (6-61)	27 ±10 (9-57)		26 ±10 (6-61)
WI (mL)	1589 ±337 (342-2902)	1863 ±335 (1140-2630)	***	1659 ±357 (342-2902)
WI/kg BW (mL)	30.4 ±8.5 (8.6-73.5)	28.2 ±7.5 (17.9-58.8)		29.9 ±8.3 (8.6-73.5)
WI during daytime (%)	95 ±5 (77-100)	95 ±5 (75-100)		95 ±5 (75-100)
WI during the evening and at night (%)	5 ±5 (0-23)	5 ±5 (0-25)		5 ±5 (0-25)
WI from major meals (%)	81 ±8 (53-96)	81 ±8 (55-94)		81 ±8 (53-96)
WI from between-meal snacks (%)	20 ±8 (4-47)	19 ±8 (6-45)		19 ±7 (4-47)

The mean daily water intake was 1589 mL (SD ±337 mL; range 342-2902 mL) in women and 1863 mL (SD ±335 mL; range 1140-2630 mL) in men (see Table 5). The mean daily water intake/kg BW was 30.4 mL (SD ±8.5 mL; range 8.6-73.5 mL) in women and 28.2 mL (SD ±7.5 mL; range 17.9-58.8 mL) in men (see Table 5). The range of mean values of water intake/kg BW between the different wards was 24.0-37.5 mL.

Almost all (97%) of the EI occurred within about 9 hours (usually from about 08:00 to 17:00) during daytime and 87% came from the major meals (i.e. breakfast, lunch and supper). Corresponding values of fluid intake were 93% (within 10 hours, usually from about 08:00 to 18:00) and 74%, respectively (see Table 5). No statistical difference was found in the relative values of the diurnal variations in EI, fluid intake and water intake between women and men (see Table 5). Patients with an EI below calculated energy requirements had a lower proportion of EI (12% vs 15%; P=0.04) and fluid intake (25% vs 28%; P=0.04) from between-meal snacks than did patients with an EI above calculated energy requirements. The diurnal variations of EI between wards, expressed as %EI from between-meal snacks, varied from 11% to 19% (P<0.001). Corresponding values for fluid intake were 22% to 34% (P<0.001).

The mean overnight period without any food was 15.2 hours and statistical differences (P<0.001) were found between the different wards. The range of mean values of overnight period without any food between wards was 14.8-15.7 hours, and the range of mean values between individuals was 11.5-16.9 hours. The mean overnight period without any intakes of beverages was 13.9 hours and there were statistical differences (P<0.001) between the different wards. The range of mean values for the overnight period without intakes of beverages between wards was 12.5-14.7 hours, and the range of corresponding mean values between individuals was 7.2-16.8 hours. There was a significant difference (P<0.001) in the EI between patients who had a shorter compared with a longer overnight period without food intake. The quartile of patients (n=54) with the shortest overnight period without food intake (of 11.5-14.9 hours) had a mean daily EI of 1769 kcal (SD ±319 kcal; range 1166-2852 kcal). The corresponding value in the quartile (n=55) with the longest period without food intake (i.e. 15.7-16.9 hours) was 1482 kcal (SD ±286 kcal; range 878-2330 kcal). No statistical difference was found in the overnight period without intake of food or beverages between women and men or between patients with an EI above and patients with an EI below calculated energy requirements.

According to the FBCE tool classification, in the study population lunch usually could be classified as "complete meals" and "prepared meals". In 1996 and 1998-1999 the supper meals could usually be classified as "complete meals" and "prepared meals" with the exception of some meals which had porridge as the main dish. By contrast, in 1995 many of the supper meals were classified as "incomplete meals". Breakfast was usually classified as an "incomplete meal" and "quick prepared meal".

In general, there were only a few patients who did not have an intake from all major meals, while there was greater variation in the frequency of intake from "between-meal snacks". Most of the patients had coffee and cake, classified as "low-quality snacks", in the afternoon. The period after supper until breakfast the next morning was often without any intake of food and with only a little fluid (see Table 5). Statistical differences were found using the FBCE tool between the different study years (see Table 6) and the different wards (data not shown), and between patients with an EI above and patients with an EI below the calculated energy requirements (see Table 7). Patients with an EI below the calculated energy requirements had fewer "complete meals", more "incomplete meals", fewer "prepared meals", more "quick prepared meals", as well as more instances of no intake between meals (see Table 7).

Out of the 220 patients only 7% received dietary supplements (liquid dietary supplements or food fortification) on a daily basis and 15% of the patients received dietary supplements at sometime during the dietary registration (see Table 1). Information on medication was retrieved from 144 subjects, 23% of whom took vitamin and/or mineral supplementation with their medication.

Table 6. *Dietary intake according to the FBCE classifications, with the 24-hour day divided into seven periods, three mealtimes and four between-meal snacks. Values are given as mean values/day. Difference in frequency between the years using Kruskal Wallis test: P-values are given as: **=P<0.01, ***P=0.001. Due to rounding the summary of the percentage does not always add up to 100%.*

	1995 (*n*=61)	**1996** (*n*=81)	**1998-1999** (*n*=78)		**All** (*n*=220)
Meals					
Complete meal	1.5 (50%)	1.8 (60%)	1.7 (57%)	**	1.6 (53%)
Incomplete meal	1.5 (50%)	1.2 (40%)	1.2 (40%)	**	1.3 (43%)
Vegetarian meal	0	0	0		0
Less balanced meal	0	0	0		0
No intake	0	0	0.1 (3%)		0.1 (3%)
Total value	**3.0 (100%)**	**3.0 (100%)**	**3.0 (100%)**		**3.0 (100%)**
Prepared meal	1.7 (57%)	2.0 (67%)	1.6 (54%)	***	1.8 (60%)
Quick prepared meal	1.3 (43%)	1.0 (33%)	1.3 (43%)	***	1.1 (37%)
No intake	0	0	0.1 (3%)		0.1 (3%)
Total value	**3.0 (100%)**	**3.0 (100%)**	**3.0 (100%)**		**3.0 (100%)**
Between-meal snacks					
High-quality snack	0.1 (2%)	0.1 (2%)	0.1 (2%)		0.1 (2%)
Low-quality snack	1.1 (28%)	1.6 (40%)	0.9 (22%)	***	1.2 (30%)
No energy snack	0.3 (8%)	0.2 (5%)	0.2 (5%)		0.3 (8%)
Mixed-quality snack	0.1 (2%)	0.2 (5%)	0.3 (8%)		0.2 (5%)
No intake	2.4 (60%)	1.9 (48%)	2.5 (63%)	***	2.2 (55%)
Total value	**4.0 (100%)**	**4.0 (100%)**	**4.0 (100%)**		**4.0 (100%)**

Table 7. *Dietary intake according to the FBCE classifications, with the 24-hour day divided into seven periods, three mealtimes and four between-meal snacks. Values are given as mean values/day. Difference in frequency between patients/residents with an energy intake (EI) above and below calculated energy requirements (ER) using Mann Whitney U-test: P-values are given as: *=P<0.05, **=P<0.01, ***P=0.001. Due to rounding the summary of the percentage does not always add up to 100%.*

	EI below ER (*n*=136)	**EI above ER** (*n*=84)	
Meals			
Complete meal	1.6 (53%)	1.8 (60%)	***
Incomplete meal	1.3 (43%)	1.1 (37%)	**
Vegetarian meal	0	0	
Less balanced meal	0	0	
No intake	0.1 (3%)	0.1 (3%)	
Total value	**3.0 (100%)**	**3.0 (100%)**	
Prepared meal	1.7 (57%)	1.9 (63%)	*
Quick prepared meal	1.2 (40%)	1.0 (34%)	**
No intake	0.1 (3%)	0.1 (3%)	
Total value	**3.0 (100%)**	**3.0 (100%)**	
Between-meal snacks			
High-quality snack	0.1 (2%)	0.1 (2%)	
Low-quality snack	1.1 (28%)	1.4 (36%)	*
No energy snack	0.3 (8%)	0.2 (5%)	
Mixed-quality snack	0.2 (5%)	0.2 (5%)	
No intake	2.3 (57%)	2.1 (52%)	*
Total value	**4.0 (100%)**	**4.0 (100%)**	

Discussion

The calculated energy requirements were not met in 62% of the patients in this study. The mean intake of vitamin B and C, calcium and zinc for the whole group was above the RDI in NNR96, but for the other nutrients the mean intake at a group level was below the RDI and even below the minimum safety level. Especially the intake of vitamin A, vitamin D, vitamin E, folate, iron and selenium was low. Small and insignificant improvements or no improvements at all were noted over the 4-year study period.

Estimated dietary recording by nursing staff in clinical settings and by using the quartile method has been shown to correlate well with the weight of food consumed (36). The used dietary record routine has been validated with doubly labelled water as the reference method (28) showing a mean over-estimation of 8% in EI and a Spearman's correlation coefficient of 0.81 compared with total energy expenditure. The reproducibility test showed a mean difference of 4% in EI and 6% in fluid intake in a test-retest study (27). In the reproducibility test of the dietary record routine it was shown that the accuracy of the method was not influenced by diagnosis, type of diet or use of supplements, functions as defined by Katz ADL index (37, 38), age, gender or length of stay on the ward. Since nursing staff served almost all food and beverages on the wards and since the same calibrated utensils were used when serving the food, we believe that the precision of the dietary recording in this study is acceptable. However, significant differences were found between the different nursing home wards, which may indicate that the method is affected by the nursing staff's interest in participating in a study and also by different routines on the wards, such as how nursing care is organised as well as the routines during mealtimes.

The same nutrient database was used for all samples to calculate nutrient content, so that a comparison between the intake during the different study years could be done without changes in the database over the study period affecting the outcome. The calculation of the nutrient in-take was based on the recipes. We did not take into account nutrient losses during the preparation and transportation of food. Such losses would affect vitamin C and to some extent thiamine, riboflavin and vitamin B6 (39). The true intake of these nutrients is therefore probably lower than reported in this study.

All methods used to estimate dietary intake have limitations and at least some degree of uncertainty (18, 40). However, the dietary record routine used in this study, has been tested in validation study (28) and reproducibility test (27) although the validation was done on energy and fluids/water. The quartile method used in the dietary record routine estimates total intake during lunch and supper, not intake of specific food items. This may lead to some uncertainty with regard to estimating vitamin and mineral intake at an individual level; however, we believe that the estimated intake at a group level is accurate. Since there is little literature thus far on the dietary

intake of frail, elderly people at a micronutrient level, we believe it is important to report our results, even if there is some uncertainty regarding some of the reported vitamin and mineral intake.

The dietary intake in geriatric patients is low. In this study 57% of the women and 77% of the men did not have a sufficient EI. With regard to vitamins and minerals, there was a large proportion who did not reach RDI levels, according to the NNR96, or even the minimum safety level of intake. The use of dietary supplements in the study population was low. In this study only 7% of the patients were given dietary supplementation on a daily basis and only 15% receive dietary supplements at some point during the dietary registration. Moreover, the use of dietary supplements decreased during the 4-year study period. Only 23% of the patients were given medical vitamin/mineral supplementation, nearly half of whom were on vitamin B12 and/or folate and/or iron supplementation and only 3% on multivitamin and/or mineral supplements. The use of dietary supplements in this study was in fact lower than that in a middle-aged Swedish population, in which 37% reported use of dietary supplements (41) and in a study of free-living healthy elderly 44% of the females and 41% of the males took supplements regularly (42). The intake of vitamin B in the present study was, however, good. This was due mainly to a high intake of bread and other cereal products which in Sweden are fortified with vitamin B. However, since the flour mills in Sweden have in the past year stopped fortifying their flour with vitamin B there will be a lower intake of riboflavin, niacin, thiamine and vitamin B6 in the future. In general, the elderly consume smaller amounts of food (43, 44), but they have the same or even higher micronutrient needs as younger people, which puts a greater demand on food planning and preparation in this group.

There is therefore a need for improvements in the mealtime situation of geriatric patients to promote an increased energy and nutrient intake. The nutritional needs of individual patients must be recognised by the nursing staff and others involved in the patients' care. The number of meals must be increased, so that there are three major meals plus three or four in-between meals per day. The overnight period without food and fluid intake should be shortened. More "complete meals", according to the FBCE classification (25), must be served. There ought to be an increased energy and protein content in the major meals without increasing the size of portion. Ödlund Olin et al (36) showed that energy-enriched meals can improve geriatric patients' EI and by using only "natural" products such as more butter, cream, crème fraîche, milk and oil, the mean EI was increased by over 800 kcal/day without any changes in the consumed amount of food (36). However, we believe that it is not enough to just increase energy and/or protein intake because a large proportion of the patients has a low micronutrient and mineral intake. A change is needed in the strategy for reducing malnourishment and malnutrition in the elderly. There is a need for a general dietary supplementation given to elderly people in sheltered housing. Instead of identifying patients at risk of malnutrition, all patients in sheltered housing should therefore be given full daily dietary supplementation, with the exclusion of people

with obesity. This is supported by the findings in this study, where the intake of vitamin D, selenium, folate, vitamin E and iron was below RDI in almost all patients. Larsson et al (16) have shown that a dietary supplements can both increase EI and reduce mortality. The nutrient quality of the between-meal snacks could also be increased as a way to increase the dietary intake, as many of the between-meal beverages served was sugar based and low nutrient soft drinks.

The high proportion of patients with an insufficient dietary intake during the 4-year study period as well as the lack of improvement in patients' dietary intake, especially for men, indicate that there seems to be a failure in the organisation of nutritional care of geriatric patients. The findings are especially interesting in the light of an intense public debate that was ongoing during the study period, about malnutrition and care of the elderly in sheltered housing in Sweden. Information and courses on nutrition have been offered to the nursing staff in the municipality where the study was performed. The difference in EI of patients was greater between wards than were the differences between the three periods of the study, which suggest that the staff's interest of and knowledge in nutritional care are of great importance. However, even in the "best" of the ten different wards in this study the mean overnight period without any food intake was almost 15 hours, with over 95% of the EI occurring over 9 hours and the EI from between-meal snacks being below 20%. In other words, it appears that the nursing staff does not ensure that the patients' individual nutritional needs are met. An important difference between patients with an EI above and patients with an EI below calculated energy requirements appears to be BW. The mean BW of patients with an EI above calculated energy requirements was 13 kg lower than the patients with an EI below calculated energy requirements. We believe that it is likely that the same amount of food and fluid is served to all patients, no matter what their individual needs might be, and that the recorded differences in dietary intake are a reflection of the patients' ability to eat and drink the served amount rather reflecting an individual difference in the served amount. This phenomenon was also observed for elderly in surgical care by Ulander et al (45).

The FBCE tool showed that patients with an EI below calculated energy requirements had ingested fewer "complete meals", more "incomplete meals", fewer "prepared meals", more "quick prepared meals", and more between-meal snacks occasions with no intake. The characteristics of the meal pattern of patients with an inappropriate dietary intake can be used as guidelines for future health strategies. The high proportions of "low-quality snacks" suggest that these should be replaced, or supplemented, with dietary supplements. Previous studies have shown that giving dietary supplements to patients with a low intake could increase their nutrient intake (46) and administration of dietary supple-ments between meals instead of with meals may be more effective in increasing the EI in the elderly (47). "Quick prepared meals", which often was also classified as "incomplete meals", should perhaps be reduced in favour of "complete meals". "Complete meals" were less often consumed among patients with a low EI. The FBCE tool has not been previously used in geriatric patients in sheltered housing for categorising their present dietary intake and

it is likely that it has to be modified to more accurately de-scribe the dietary intake of residents living in sheltered housing. For example, the intake of dietary supplements has been categorised as "category F - low nutrient density" (see Appendix 1) even though liquid dietary supplements are balanced and complete. Also, there is no simple way of reporting an increased EI with the FBCE tool. Some adjustments were already made in using the FBCE tool in this study for categorising porridge (see Appendix 1). Possibly could more figures could be found if using the tool also to describe the diurnal variations in intake of different nutrients.

Almost all (97%) of the EI in this study occurred during about 9 daytime hours (usually from about 08:00 to 17:00). The mean overnight period without any food intake was about 15 hours, which finding is in agreement with that reported by Bachrach-Lindström in a study performed in nursing homes (48). The recommended maximum of overnight period without any food is 11 hours (32). Patients who had a shorter overnight period with out any food intake (lowest quartile) had a mean daily EI of almost 300 kcal more than did patients with longer overnight period with out any food intake (highest quartile). By the same token, patients with more meals/day (highest quartile) had a mean daily EI of almost 300 kcal more than did patients with fewer meals/day (lowest quartile). Only a few of the major meals were served without any intake in individual patients, but only about 13% of the EI came from between-meal snacks.

The recommended daily fluid intake in elderly people is 30 mL/kg BW (49). However, it is not clear whether this amount refers to fluid intake or to water intake, calculated from both food and fluid intake. The mean daily fluid intake of about 22 mL/kg BW in this study is far below the recommended amount, but if the water intake is taken into account, the mean daily intake in the present study was about 30 mL/kg BW.

The mean daily fluid intake in men was only about 100 mL more than that in women despite a difference in mean BW of 14 kg. Taking mean BW into consideration therefore showed that men had a lower daily fluid intake than women did. The result suggests that the individual needs for fluid were not being met. Other studies have shown that geriatric patients do not have a sufficient fluid intake (50) and that dehydration in the institutionalised elderly can be an indicator of inadequate care (51). Blower (52) reports that patients, who are thirsty but unable to drink independently, often wait to ask for help because they do not want to disturb the nursing staff. Adams (53) showed that 75% of the fluid intake by geriatric patients takes place during 12 hours (usually from 06:00 to 18:00) during daytime and that the patients often drink the entire amount offered. In our study about 93% of the fluid intake happened during 10 hours (usually from 08:00 to 18:00) and about 74% of the fluid intake took place during the major meals of breakfast, lunch and supper. Since we did not record the actual time at which the beverages were consumed, but instead recorded the times at which beverages were served, the present data on the overnight period without fluid intake may be more imprecise than those on non-intake of

food since not all fluid intake always take place immediately when served. Voluntary avoidance of fluids during the evening and at night in residents who need toilet assistance should also be taken into account (54).

Insufficient awareness of patients' individual nutritional needs by nursing staff has been previously described in surgical care (45). Sidenvall et al (55, 56) found that mealtime procedures at institutions for elderly people are often governed by the nursing staff's routines and not by individual patients' needs, with mealtimes being more task-oriented than patient-oriented and therefore failing to meet the patients' nutritional needs. Other studies have also shown a lack of knowledge in assessing patients' nutritional needs, as well as inadequate action to meet these needs (57, 58).

Despite the observed situation of no or only little improvement during the 4 study years, there are ways to improve patients' nutritional care. Olsson et al (59) showed that education and training programme for nurses can improve nutritional assessments and interventions. Elmståhl et al reported the finding that a changed meal environment (60) or supplementation (46) may increase the patients' EI by as much as 25%. Christensson et al (61) showed that nursing care based on individual nutritional requirements, resources and de-sires can improve dietary intake, nutritional status and functional capacity in malnourished geriatric patients. Ödlund Olin et al (36) showed that energy-enriched meals can improve patients' EI. Likewise, Larsson et al (16) found that dietary supplements can both increase EI and reduce mortality, and Wilson et al (47) found that administration of dietary supple-ments between meals instead of with meals may be more effective in increasing the EI in the elderly. In summary, it is crucial that nursing staff is appropriately trained in assessing patients' dietary intake. Pokrywka et al (62) suggest that a feasible solution would be to develop a standardised training programme to be offered to nursing staff at regularly scheduled intervals to compensate for the large turnover in nursing staff.

Conclusions

Almost the entire EI in the present study occurred within 9 hours during daytime. There was a mean overnight period without any food intake and only a little fluid of 15 hours. Only about 13% of the total EI came from between-meal snacks. Sixty-two per cent of the patients had an EI below calculated energy requirements. There is a lack of ability in nursing staff to identify and correctly estimate geriatric patients' nutritional needs. A change in the strategy for preventing malnutrition in the elderly is therefore clearly needed. There is a need of general daily dietary supplementation to be given to all elderly people living in sheltered housing. This means that instead of identifying patients at risk of malnutrition all patients in nursing homes and residents in community residence homes should be given full daily dietary supplementation.

Acknowledgements

We are grateful to dietician Margaretha Andrén, dietician Vlasta Blabolil, and catering manager Birgitta Heuck-Lawesson, for their skilful help in compiling data.

This study was supported by grants from: Lund University, Lund, Sweden; the Municipality of Malmö, Malmö Sweden; Påhlsson's Foundation, Malmö, Sweden; the Swedish Foundation for Health Care Sciences and Allergy Research, Stockholm, Sweden (grant No. V97-234 and V99-090); the Swedish Nutrition Foundation, Lund, Sweden; the Swedish Society of Nursing, Stockholm, Sweden; the Gun and Bertil Stohnes Foundation, Stockholm, Sweden; the Family Janne Elqvist Foundation, Nybro, Sweden; and the Loo and Hans Ostermans Foundation for Geriatric Research, Stockholm, Sweden.

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Appendix 1. *Description of the "Food-based Classification of Eating Episodes (FBCE)" (25). Food categories and their nutrient properties as the basis for categorisation of eating events.*

Category				
A	Animal origin	Meat and meat products, fish and shellfish, poultry, egg, milk and cheese	High nutrient density	Animal protein and fat, iron, zinc, calcium
B	Plant origin	Rice, pasta, bread, dried legumes, seeds, potatoes	High nutrient density	Starch, plant protein, dietary fibre
C	Plant origin	Green vegetables, fruit, berries, roots	High nutrient density, low energy density	Starch, carontenoids, ascorbic acid
D	Plant origin	Nuts, olives, avocado	High fat density	Plant fat, protein
E	Animal and plant origin	Cooking fat, spreads, cream, fatty sauces	High fat density	Fat
F	Plant origin	Products in which white sugar is often added, beverages containing alcohol, ice cream, sweets, chocolate, biscuits, sweet desserts	Low nutrient density	Sugar, fat, alcohol
G		Water, coffee, tea, unsweetened light beverages	No energy	No nutrients

Criteria for the categorisation of eating episodes according to the combination of food categories and examples of food composition in types of meals and snacks.

	Meals	*Example*
A+B+C	Complete meal	e.g. meat, potatoes or bread, carrots
A+B	Incomplete meal	e.g. meat, potatoes or bread
A+C	Less balanced meal	e.g. meat, carrots
B+C	Vegetarian meal	e.g. potatoes or bread, carrots

	Snacks	*Example*
A or B or C	High-quality snacks	e.g. an apple
Any of A or B or C and/or D and/or E and/or F	Mixed-quality snacks	e.g. an apple and some chocolate
E and/or F	Low-quality snacks	e.g. some chocolate
G	No energy snacks	e.g. coca cola light, water

Level of preparation of meals
For a sub-categorisation of meals with respect to the level of preparation the meals breakfast, lunch and supper have also been categorised as "prepared meal" or "quick-prepared meal". Meals including rice, potatoes, pasta, pizza dough or pie shells are considered as "prepared", and most of them require a knife and fork to eat. A meal is considered to be "quick-prepared" when the starch component (food category B) consists of breakfast cereals and bread. Milk-based porridge has in this study been categorised as "prepared meal", while water-based porridge has been categorised as a "quick-prepared meal".

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