

ORIGINAL ARTICLE

Nutritional status, as determined by the Mini-Nutritional Assessment, and osteoporosis: a cross-sectional study of an elderly female population

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Objective: To investigate the relationship between osteoporosis and nutritional status as determined by the Mini-Nutritional Assessment (MNA).

Design: A cross-sectional study.

Setting: Stockholm, Sweden.

Subjects: A total of 351 elderly free-living women (mean age 73 ± 2.3 years).

Methods: MNA (range 0–30 points; <17 indicates malnutrition, 17.5–23.5 risk of malnutrition and ≥ 24 well nourished), measurements of bone mineral density of the left hip and lumbar spine using Hologic QDR 4500, and of the heel using Calscan DEXA-T.

Results: The median MNA score was 27 (range 12.5–30). One woman was classified as malnourished and 7.4% were at risk of malnutrition. Osteoporosis of the femoral neck was observed in 22% and a fracture after the age of 50 was reported by 31% of the participants. The following items in the MNA questionnaire exhibited an increased risk of having osteoporosis in the femoral neck and/or total hip: an MNA score of <27 (odds ratio (OR) = 2.09; CI = 1.14–3.83); a mid-arm circumference of less than 28 cm (OR = 2.97; CI = 1.29–6.81); and regular use of more than 3 drugs each day (OR = 2.12; CI = 1.00–4.50). A body weight of more than 70 kg exhibited a decreased risk of having osteoporosis (OR = 0.31; CI = 0.14–0.70).

Conclusions: In general, the nutritional status was good in this population of free-living elderly women. Nevertheless, half of the women who displayed an MNA score <27 points had a twofold increased risk of having osteoporosis.

Sponsorship: Karolinska Institutet, Stockholm County Council.

European Journal of Clinical Nutrition (2006) 60, 486–493. doi:10.1038/sj.ejcn.1602341; published online 14 December 2005

Keywords: osteoporosis; nutritional status; Mini-Nutritional Assessment; elderly women

Introduction

Osteoporosis is a major health problem, increasing the risk of fragility fractures. The World Health Organization (WHO) defines osteoporosis on the basis of reduced bone mineral density (BMD) (WHO, 1994). Low BMD, one of the strongest

risk factors for fracture, can easily be determined by dual-energy X-ray absorptiometry (DXA) and used to predict the risk of fractures in elderly women (Cummings *et al.*, 1993; Marshall *et al.*, 1996; Siris *et al.*, 2001).

Nutrition is an important factor in the health status of elderly people, and malnutrition is known to affect bone metabolism. Furthermore, low body weight has consistently been shown to be associated with an enhanced risk of osteoporosis (Dargent-Molina *et al.*, 2000). The Mini-Nutritional Assessment (MNA), a test developed to determine the risk of malnutrition in older people (Guigoz *et al.*, 1996), has been employed to detect nutritional deficiencies in institutional settings (Saletti *et al.*, 2000) as well as in healthy general populations (Scheirlinckx

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Received 11 April 2005; revised 31 August 2005; accepted 21 September 2005; published online 14 December 2005

et al., 1999). Moreover, this test has been found to predict mortality in geriatric patients (Persson *et al.*, 2002) and in both an elderly Danish population and among free-living elderly Swedish subjects receiving public services and care (Beck *et al.*, 2001; Saletti *et al.*, 2005). In a comparison of ultrasound measurements of the calcaneus with MNA test scores in a population of institutionalized elderly women, Gerber *et al.* (2003) observed no correlation at all between the MNA score and the ultrasound parameter Speed of Sound (SOS) and only a weak trend towards a correlation with the Broadband Ultrasound Attenuation (BUA).

The primary aim of the present study was to determine whether there is an association between BMD as assessed by DXA and the nutritional status indicated by the MNA questionnaire in a group of elderly women, living at home. To our knowledge, no study of this nature has been reported previously.

Subjects and methods

Study population

The individuals included in this cross-sectional study, which is part of the larger PRIMOS (Primary Health Care and Osteoporosis) project, were recruited from the population of approximately 940 women born between 1920 and 1930 and living in the area serviced by the Bagarmossen primary health care centre in the southern region of Stockholm.

The women were invited to participate in two stages. First, 300 women were selected randomly from the total population. The women were sent letters, with reminders to those who did not reply. In the second stage all the remaining 284 women born between 1926 and 1930 were invited to participate. Thus, of the total study sample of 584 women, 351 (60.1%) were included in this study. Of these participants 87.5% were of Swedish descent, 3.1% originated from Finland, 2.6% from Norway, 0.6% from Denmark, and only 6.0% from countries outside Scandinavia.

The only criterion for inclusion was that the women should be mobile and able and willing to visit the primary health care centre and the hospital for measurements of BMD. This excluded most of the women living in assisted-accommodation institutions for the elderly, such as old people's homes and nursing homes. Only 2% of the participants received home care services.

The first woman was recruited in March 1999 and the last in February 2001.

Ethical approval was obtained from both the Local Ethics Committee at Karolinska University Hospital Huddinge and the Radiation Protection Committee at Karolinska University Hospital Solna. Furthermore, informed consent was obtained from all the participants prior to their inclusion.

Characterization of nonparticipants

A 'drop-out analysis' was performed in order to determine whether the participants differed from nonparticipants. A

Table 1 Characteristics of the women who declined to participate in this study ($n=233$; age 73.9 ± 2.6 years (mean \pm s.d.))

Parameter	Percentage of nonparticipants	Participants
Answered the 'drop-out analysis' questionnaire	46.4	—
Diagnosed as having osteoporosis	7.4	7.1
History of fracture at any site	25.9	30.9
Hip fracture	4.6	1.4
Wrist fracture	12.0	22.5
<i>Self-assessment of health^a</i>		
Worse than others	15.7	6.4
As good as others	35.2	35.0
Better than others	19.4	46.1
Cannot compare	25.9	12.4

^aIn comparison to the health of other women of approximately the same age.

questionnaire was sent to all women who declined to participate. This questionnaire was answered by 46.4% of the nonparticipants. The women who participated were of a mean age (72.9 years) that was 1 year younger than that of the nonparticipants (73.9 years). As seen from the characteristics of those who declined to participate, documented in Table 1, a history of wrist fracture was more common among the participants (22.5%) than among the nonparticipants (12.0%) ($P=0.047$). In addition, more women among the nonparticipants (4.6%) than participants (1.4%) reported having suffered a hip fracture ($P=0.053$).

The first 16 women who declined to participate were also interviewed by telephone. A majority of them (12) declined because they were too ill and eight of them especially mentioned that they were not mobile enough to be able to manage to come to the visits at the health care centre and the hospital. Four of the interviewed 16 women simply were not interested in participating.

The MNA

The MNA questionnaire employed here to evaluate the nutritional status of our subjects consists of 18 weighted questions divided into four sections: *Anthropometric measurements*, that is, body mass index (BMI), circumferences of the mid-upper arm and calf, and weight loss during the past three months; *Global evaluation*, the type of living accommodation, use of medication taken on a regular basis, acute diseases, mobility, neuropsychological problems, and pressure sores or skin ulcers; *Dietetic assessment*, number of whole meals consumed and choice of food, intake of fluid daily, and possible requirement for help in eating; *Self-assessment*, the perceived adequacy of food intake and self-perception of health.

The maximum MNA score is 30 points, with scores <17 indicating malnutrition, 17–23.5 points indicating risk of malnutrition, and >24 points showing an adequate nutritional status.

The MNA questionnaire was filled out during the women's visit to the health care centre. During this visit, weight (in kg), height (in cm) and mid-arm and calf circumferences were measured and the women answered the questions orally during a face-to-face interview. BMI was calculated as body weight in kg divided by the square of the height in m. For purposes of standardization, only one of the authors (HS) had contact with all of the participants in connection with this visit. For the measurement of the mid-upper arm circumference, the nondominant side (most often the left) was used. Calf circumference was measured on the left side. In order to assess the adequacy of the food portions, the subjects were asked to compare their portions with pictures showing different-sized portions. Fluid intake was estimated by asking how many glasses containing 200 ml of fluid the subject drank each day.

The MNA scores have been shown to demonstrate both a high sensitivity (98%) and specificity (96%) (Guigoz *et al.*, 1996). The MNA scores have also been shown to correlate significantly to the intake and levels of a number of nutritional and physiological parameters, including energy, carbohydrates, vitamin D, 25-OH-cholecalciferol, albumin, and transferrin (Vellas *et al.*, 2000). With respect to the reliability of this assessment, Bleda *et al.* (2002) reported an intraclass correlation coefficient (ICC) of 0.89 for the test-retest reliability and an internal consistency with Cronbach's alpha values of 0.83 and 0.74 upon second administration.

Evaluation of risk factors for osteoporosis

Risk factors for osteoporosis were evaluated during the study visit using a questionnaire the subjects had answered at home prior to the visit and additional questions during the face-to-face interview. The clinical status of the subjects was examined and the medication they used was evaluated.

Measurement of BMD

The BMD measurements of the hip, spine, and calcaneus were performed at Karolinska University Hospital Solna by specially trained staff. The bone mineral densities of the lumbar spine (L1–L4 in anteroposterior projection) and of the hip were measured utilizing Hologic QDR 4500 DXA equipment (Hologic Inc., Waltham, MD, USA), while that of the calcaneus was determined with the Calscan DEXA-T device (Stille AB, Stockholm, Sweden). Studies of precision were performed in the study population with both technologies (Salminen *et al.*, 2005).

Measurements of the calcaneus and the lumbar spine were performed in 346 women. Five women completed the visit and the evaluation with the MNA, but were not measured with bone mineral densitometry for various reasons. In six of the 346 women measurement of the hip was not possible due to the presence of bilateral hip-joint prostheses. Only the left hip was measured (if not impossible due to an artificial hip-

joint at the left side, necessitating the measurement of the right hip instead).

T-score values for the lumbar spine were obtained directly from the DXA device using the manufacturer's reference material, whereas *T*-scores for the hip were calculated employing the NHANES III bone normative data (Looker *et al.*, 1995). The NHANES III bone normative data were used as a reference population since these BMD values are considered also to be representative of Swedish women, as shown by Lofman *et al.* (1997).

The cutoff points suggested by the WHO (1994) were applied to classify subjects as normal (a *T*-score -1 s.d. or above the mean for the young adult female reference population), osteopenic (a *T*-score between -1 and -2.5 s.d. below this mean), and osteoporotic (a *T*-score -2.5 s.d. or more below this mean).

For the calcaneal device, *T*-scores were calculated using the Swedish Calscan reference population (Kullenberg, 2003) following conversion of the DEXA-T BMD values to Calscan DXL BMD values (Salminen *et al.*, 2005).

Z-scores for the spine were obtained directly from the DXA device, while the corresponding values for the hip were calculated using the NHANES III reference population and for the heel using the Calscan reference population.

Statistical analysis

In the analysis of the MNA questionnaire, the only subject identified as malnourished was grouped together with the subjects at risk of malnutrition. ROC analysis was performed to show the capacity of the items in the MNA questionnaire to discriminate osteoporotic subjects from those not having this condition. The value of acceptance for statistical significance was set at $P < 0.05$.

Unconditional logistic regression (Kleinbaum and Mitchel, 2002, 1994) was employed to analyse the relationship between osteoporosis and the items in the MNA questionnaire.

The outcome variable was dichotomized into osteoporotic (*T*-score ≤ 2.5 s.d.) and nonosteoporotic (reference) at the femoral neck and/or total hip.

The explanatory variables were the following. *The MNA score*, divided into two groups with medians equal to or above 27 (reference) and below 27. In our material only 27 women were at risk of malnutrition and only one woman was malnourished. We therefore chose to use the median MNA score as the cutoff point in our logistic regression model; *Age*, grouped into those under (reference) or over 75 years of age; *Weight*, divided into groups of 45–55, 56–69, (reference) and 70–126 kg. Weight, and not BMI, was employed in the logistic regression model, since weight exhibited a closer association with BMD; *Mid-arm circumference (MAC)* (in cm), divided into groups of 22–27, 28–31, (reference) and 32–47 cm; *Medication*, grouped into those regularly taking more or less (reference) than three different drugs each day.

The dichotomous variables tested that did not improve the model were the presence or absence of weight loss during the last 3 months; autonomous or assisted living; experience or lack of psychological stress or acute illness during the last 3 months; presence of mild dementia (Berger scale I and II) or lack of neuropsychological problems; having or not having a pressure sore or ulcer; intake of fruit or vegetables at least twice a day; fluid intake of 3–5 or >5 cups per day; requirement for assistance with feeding; and the subject's own view of the presence or absence of nutritional problems. The variables grouped into several levels that did improve the model were the number of complete meals per day (three levels), protein intake (three levels), declining food intake (three levels), and self-assessed health (four levels).

The logistic regression model was tested for interactions and for collinearity. For model improvement the likelihood ratio test was carried out and a *P*-value <0.05 considered as indicating significant improvement. The model fit was examined using Pearson's goodness-of-fit test, with a *P*-value >0.05 judged as a good fit. The results are expressed as odds ratios (OR) with 95% CI.

All the statistical analyses were performed with STATA statistical software release 8 (Stata Corporation, College Station, TX, USA).

Results

The participants in this study exhibited a high median MNA score of 27 (range 12.5–30). Only one subject could be considered malnourished; 7.4% (27) were at risk of malnutrition; and the nutritional status of the remaining 92.4% (323) was adequate according to the MNA.

The characteristics of the 351 participants are documented in Tables 2a and b. The *Z*-scores show values around zero, meaning that the women had BMD values comparable to an age-matched reference population and the subjects with MNA scores ≤23.5 had significantly lower *T*- and *Z*-scores in

the femoral neck, total hip, and the heel, but a nonsignificant difference in the lumbar spine. The proportion of our subjects not taking any medication at all on a regular basis was 16.2%. The women at risk of malnutrition had significantly higher use of loop diuretics and suffered more often from ischemic heart disease and chronic lung disease.

The consumption of milk and yoghurt did not differ between the groups (mean daily consumption 3.4 dl, data not shown in the tables) but more women among those at risk of malnutrition (11.1%) never consumed cheese compared to the well nourished (1.2%). More women among those at risk of malnutrition (59%) never used alcohol compared to the well nourished (32.5%).

Table 3 presents a summary of the results of the MNA questionnaire. The women at risk of malnutrition used more drugs; acute illness, weight loss, and/or psychological stress during the preceding 3 months were more common; few ate more than two complete meals each day; and a moderately reduced appetite was common. The women appeared to be able to assess their own health status relatively well.

All of the anthropometric measurements, that is, BMI, weight and mid-arm and calf circumferences other than height, exhibited highly significant correlations with the BMD values (*P*-values <0.001). The Spearman correlation coefficient at all sites of measurement indicated a better correlation between BMD and weight (0.42–0.47) than between BMD and BMI (0.38–0.44). The weight and the MNA scores of the women correlated negatively with their age (Spearman correlation coefficients of –0.11, *P*=0.038 and –0.18, *P*<0.001, respectively). Their BMI values showed no significant correlation with their MNA scores (Spearman correlation coefficient of 0.05, *P*=0.374).

The age-adjusted OR for women with an MNA score of <27 to suffer from osteoporosis in the femoral neck was 1.89 (CI = 1.11–3.19); in the total hip 2.04 (CI = 1.05–3.96); in the spine 1.07 (CI = 0.66–1.74); and in the calcaneus 1.09 (CI = 0.70–1.69). The women at risk of malnutrition (MNA

Table 2a Descriptive characteristics of the 351 women participating in this study

Parameter	All women (n = 351)		MNA ≤ 23.5 (n = 28)		MNA ≥ 24 (n = 323)		P-value*
	Mean ± s.d.	% T-score ≤ –2.5	Mean ± s.d.	% T-score ≤ –2.5	Mean ± s.d.	% T-score ≤ –2.5	
Age (years)	72.9 ± 2.4	—	74.1 ± 2.4	—	72.8 ± 2.3	—	0.003
Weight (kg)	69.8 ± 12.1	—	65.1 ± 3.8	—	70.2 ± 11.9	—	0.030
Body mass index (kg/m ²)	27.1 ± 4.5	—	25.9 ± 5.5	—	27.2 ± 4.4	—	0.151
<i>Bone density (s.d.)</i>							
T-score femoral neck	–1.8 ± 0.9	22.4	–2.5 ± 1.1	40.0	–1.8 ± 0.9	21.0	0.023
Z-score femoral neck	0.3 ± 1.0	—	–0.1 ± 1.2	—	0.3 ± 1.0	—	—
T-score total hip	–1.2 ± 1.2	12.4	–1.9 ± 1.5	32.0	–1.2 ± 1.1	10.8	0.003
Z-score total hip	0.6 ± 1.1	—	0.0 ± 1.4	—	0.7 ± 1.1	—	—
T-score lumbar spine	–1.6 ± 1.5	27.8	–1.9 ± 1.4	30.8	–1.6 ± 1.5	27.5	0.336
Z-score lumbar spine	0.7 ± 1.5	—	0.5 ± 1.4	—	0.7 ± 1.5	—	—
T-score left heel	–2.4 ± 0.9	44.2	–3.0 ± 1.3	61.5	–2.3 ± 0.9	42.8	<0.001
Z-score left heel	–0.1 ± 0.9	—	–0.6 ± 1.2	—	0 ± 0.8	—	—

Table 2b Risk factors for osteoporosis, medication and chronic diseases of the subjects

	All women (n = 351) (Percentage)	MNA \leq 23.5 (n = 28) (Percentage)	MNA \geq 24 (n = 323) (Percentage)	P-value*
Diagnosis of osteoporosis prior to the study	7.1	17.7	6.2	0.022
History of fracture after the age of 50	30.9	42.3	30.0	0.192
History of wrist fracture	22.5	14.3	23.2	0.748
History of hip fracture	1.4	3.6	1.2	0.318
Current smoker	15.4	14.3	15.5	0.986
<i>Medication on regular basis</i>				
Calcium and vitamin D	7.4	14.3	6.8	0.149
Bisphosphonates	2.3	7.1	1.9	0.072
Thiazides/Thiazide-related	8.0	7.1	8.1	0.862
Loop diuretics	8.9	35.7	6.5	<0.001
Levothyroxin	15.4	28.6	14.2	0.044
Corticosteroids orally	1.7	3.6	1.6	0.428
Corticosteroids inhaled	7.1	10.7	6.8	0.441
<i>Chronic diseases</i>				
Diabetes	8.3	10.7	8.1	0.623
Ischemic heart disease	15.7	35.7	13.9	0.002
Hypertension	18.5	7.1	19.5	0.106
Breast cancer	8.3	14.3	7.7	0.227
Chronic lung disease	10.3	25.0	9.1	0.007

*P-value for the difference between the subjects with MNA \leq 23.5 (n = 28) and subjects with MNA \geq 24 (n = 323).

score \leq 23.5) demonstrated a significantly elevated age-adjusted risk (OR 2.38 CI = 1.02–5.59) of having osteoporosis in the femoral neck and/or total hip.

The items in the MNA questionnaire which were most strongly associated with osteoporosis in the femoral neck and/or total hip are documented in Table 4. Women weighing less than 56 kg exhibited a 2.5-fold elevation in risk of having osteoporosis compared to those with a weight of 56–69 kg, and a body weight of more than 70 kg was seen to exert a protective effect. However, when the circumference of the mid-arm was also factored into the model, this influence of low body weight was no longer significant. Instead, a mid-arm circumference of less than 28 cm proved to be the strongest risk factor in the case of the full model, being associated with a risk of osteoporosis which was three times higher than the risk of those in the reference category (i.e., with a mid-arm circumference of 28–31 cm).

In the main effect model women with an MNA score less than the median score of 27 demonstrated a twofold elevation in risk of osteoporosis compared to those with a score above this median. In addition, women taking more than three drugs daily demonstrated a twofold elevated risk in comparison to those using fewer drugs. ROC analysis of the relationship between osteoporosis in the femoral neck and/or total hip and the explanatory variables of the main effect logistic regression model revealed a moderately high area under curve (AUC) of 0.76.

The coexisting diseases influenced the risk of having MNA scores indicating the risk of malnutrition more than the risk of having osteoporosis. The subjects with the diagnosis of ischemic heart disease (n = 55) had an over threefold

increased age-adjusted risk of having MNA scores \leq 23.5 (OR = 3.1; CI = 1.31–7.23) and a decreased risk of having osteoporosis (OR = 0.4; CI = 0.14–0.87). The subjects with a chronic lung disease (n = 36) had a fourfold increased age-adjusted risk of having an MNA scores \leq 23.5 (OR = 4.1; CI = 1.55–10.85) and a nonsignificantly increased age-adjusted risk of having osteoporosis (OR = 1.9; CI = 0.88–4.18).

The use of any single drug was not significantly associated with the women's risk of having osteoporosis, but especially the use of loop diuretics influenced the women's risk of having MNA scores \leq 23.5 (age-adjusted OR = 6.9; CI = 2.8–17.3).

Discussion

The fact that the elderly women living autonomously and participating in this study had a median MNA score of 27 points indicates that their nutritional status was good. Using the WHO criteria, osteoporosis was detected in the femoral neck in 22% of these subjects, but only one suffered from malnutrition as assessed by the MNA instrument. Surprisingly, this investigation reveals that even a slight deterioration in nutritional status is associated with an enhanced risk of osteoporosis. Women whose MNA score was below the median score exhibited a twofold higher risk of having osteoporosis in the femoral neck and/or total hip than those with a score above the median.

Previous studies involving other tests for nutritional screening have also shown that only 1–5% of free-living elderly Swedes are malnourished (Thorslund *et al.*, 1990; Cederholm and Hellstrom, 1992). The median MNA score of

Table 3 Assessment of the participants with the MNA questionnaire

Parameter	All women (n = 351)	MNA \leq 23.5 (n = 28)	MNA \geq 24 (n = 323)
1. Anthropometric measurements (Mean \pm s.d.)			
Mid-arm circumference (cm)	30.5 \pm 3.7	29.2 \pm 4.3	30.6 \pm 3.7
Calf circumference (cm)	35.6 \pm 3.0	35.1 \pm 4.7	35.7 \pm 2.7
Loss of weight during the last three months (%)	8.6	46.4	5.3
2. Global assessment (%)			
Autonomous living	99.7	96.5	100
Intake of more than three different drugs each day	24.5	60.7	21.4
<i>Mobility</i>			
Bed- or chairbound	0	0	0
Housebound	0	0	0
Mobile (goes out)	100	100	100
Psychological stress or acute disease During the last 3 months	21.9	78.6	17.0
<i>Neuropsychological assessment</i>			
Severe dementia or depression	0	0	0
Mild dementia	2.6	10.7	1.9
No neuropsychological problems	97.4	89.3	98.1
Pressure sore or ulcer	0.6	0	0.6
3. Dietary assessment			
<i>Number of complete meals per day</i>			
1 meal	11.1	40.7	8.7
2 meals	66.3	55.6	67.2
3 meals	22.6	3.7	24.1
<i>Protein intake</i>			
Score 0	4.3	10.7	3.7
Score 0.5	41.6	57.1	40.3
Score 1	54.1	32.1	56.0
Fruits or vegetables at least twice a day	89.2	82.1	89.8
<i>Decline in food intake</i>			
Severely reduced appetite	0.6	3.6	0.3
Moderately reduced appetite	6.0	42.8	2.8
Normal appetite	93.4	53.6	96.9
<i>Daily consumption of fluid (water, coffee, juice, milk etc.)</i>			
3–5 cups per day	6.0	7.1	5.9
> 5 cups per day	94.0	92.9	94.1
<i>Mode of eating</i>			
Independent with some assistance	0.3	0	0.3
Independent	99.7	100	99.7
4. Self-assessment of nutrition and health			
<i>Subjective nutritional assessment</i>			
Views self as being malnourished	0	0	0
Moderate malnutrition or is uncertain	0.9	10.7	0
No nutritional problems	99.1	89.3	100
<i>Subjective health assessment^a</i>			
Health not as good as others	10.3	53.6	6.4
Uncertain	12.8	17.8	12.4
As good as others	33.6	17.8	35.0
Better than others	43.3	10.7	46.1

^aIn comparison with others about the same age.

27 points observed here is similar to that reported by others for elderly noninstitutionalized individuals who have aged successfully (Scheirlinckx *et al.*, 1999). In our investigation only 7.4% of the women were at risk of malnutrition, a proportion comparable to that found by Maaravi *et al.* (2000) in the Jerusalem longitudinal study of 70-year-olds, in which 8.3% of the 605 of the persons of this age still living at home were examined in a cross-sectional fashion and found to be

at risk of malnutrition. Subjects living in assisted accommodation show a much higher percentage of malnutrition; 36.5% of the subjects in the study by Saletti *et al.* (2000) were assessed as malnourished using the MNA instrument. Older people living at home receiving regular home-care services are also more at risk than the free-living elderly of our study, as shown by Soini *et al.* (2004), who found, also using the MNA instrument, that 3% of the subjects in their study were

Table 4 The risk (Odds ratio, OR, with 95% confidence interval, CI) of osteoporosis in the femoral neck and/or total hip as analysed by logistic regression, (*n* = 340)

Variable	Level	OR (CI) using the model		Weight included	MAC included	Main effect
		Crude	Age-adjusted			
Age (years)	<75	—	1 (reference)	1 (reference)	1 (reference)	1 (reference)
	≥75	—	1.96 (1.08–3.57)	1.86 (0.98–3.55)	1.73 (0.89–3.36)	1.85 (0.94–3.63)
MNA score	< 27	1.92 (1.16–3.18)	1.78 (1.06–2.98)	1.74 (0.99–3.05)	1.70 (0.96–3.00)	2.09 (1.14–3.83)
	≥27	1 (reference)	1 (reference)	1 (reference)	1 (reference)	1 (reference)
Weight (kg)	45–55	—	—	2.49 (1.14–5.44)	1.40 (0.55–3.61)	1.19 (0.45–3.14)
	56–69	—	—	1 (reference)	1 (reference)	1 (reference)
	70–126	—	—	0.28 (0.15–0.53)	0.27 (0.12–0.60)	0.31 (0.14–0.70)
MAC ^a	22–27	—	—	—	2.64 (1.18–5.92)	2.97 (1.29–6.81)
	28–31	—	—	—	1 (reference)	1 (reference)
	32–47	—	—	—	1.73 (0.76–3.97)	1.59 (0.69–3.63)
Medication	> 3 drugs	—	—	—	—	2.12 (1.00–4.50)
	≤ 3 drugs	—	—	—	—	1 (reference)
Deviance	0.04	—	—	2.01	12.89	24.46
Degrees of freedom	4	—	—	12	27	45
P-value	0.83	—	—	0.95	0.88	0.94

^aMid-arm circumference.

malnourished and 48% were at risk of malnutrition. Similar results were found in the study by Saletti *et al.* (2005), who found that 8% of the elderly receiving public services and home care were malnourished and around 40% were at risk of malnutrition. The 3-year mortality was highly elevated for the malnourished and those at risk of malnutrition, 50 and 40%, respectively. In addition, patients seen by the general practitioners appear to differ in this respect from the free-living elderly in the general population because the doctor is normally contacted when there is a medical problem generating a 'sick' study population effect. This explains why in the study by Beck *et al.* (2001) 38% of the patients with a mean age of 75 years coming from a Danish general practice obtained an MNA score of 17–23.5 points, indicating them to be at risk of malnutrition.

Many nutritional factors, such as protein intake, calcium, and vitamin D, are known to affect BMD, which is highly significantly correlated to body weight and BMI. Many patients with osteoporotic hip fractures have previously been found to be undernourished and suffering from protein-energy malnutrition (PEM) (Ponzer *et al.*, 1999). Osteoporosis is also a predictor of mortality (Johnell *et al.*, 2004) and, likewise, the MNA has been found to predict mortality in geriatric patients both during short-term stays in the hospital (Van Nes *et al.*, 2001) and during a long-term 3-year follow-up (Persson *et al.*, 2002).

To our knowledge, this is first report concerned with the possible association between BMD (measured by DXA) and nutritional status assessed with MNA to be published. One earlier study concluded that there was only a weak correlation and trend between the calcaneal ultrasound parameters of BUA and SOS or Stiffness and the MNA score (Gerber *et al.*, 2003). In this study by Gerber and coworkers, all the studied subjects were institutionalized and they demonstrated a much lower median MNA score than did our participants.

The calcaneal BMD in our subjects (measured by DXL) exhibited similar, but weaker associations with various items in the MNA questionnaire than did the corresponding values for the hip and spine.

Another notable finding presented in our study is that BMD in elderly women is less closely correlated to their BMI than to their body weight. Many elderly women suffer from vertebral compression fractures, one-third of which are never diagnosed clinically (Cooper *et al.*, 1992). Height reduction from this or any cause increases the BMI of these women.

Surprisingly, in our investigation, a thin mid-arm circumference was associated with a higher OR for having osteoporosis than low body weight. In fact, this former parameter was associated with the highest OR, that is, a threefold elevated risk of osteoporosis in women with a mid-arm circumference of less than 28 cm, compared to women with a corresponding circumference in the middle range. The main effect logistic regression model also indicated that a very large mid-arm circumference may be associated with an increased risk of having osteoporosis, but this observation was not statistically significant.

Our subjects who were regularly taking more than three drugs each day exhibited a two-fold elevation in risk of osteoporosis in comparison to those using fewer drugs. Perhaps polypharmacy is an indicator of a general decline in health status that also affects the skeleton. For instance, Valtola and coworkers found that subjects regularly taking more than three drugs each day suffered twice as many ankle fractures during the 5-year follow-up period (Valtola *et al.*, 2002). In our study, MNA scores indicating risk of malnutrition were more associated with coexisting diseases and medications than with the women's risk of having osteoporosis. Surprisingly, women in this study with the diagnosis of ischemic heart disease had a decreased risk of having osteoporosis while their risk of being at risk of malnutrition

was threefold elevated. The use of loop diuretics most probably reflects a more severe state of heart disease and frailty and the subjects using these drugs had an almost 7-fold elevated risk of being at risk of malnutrition compared with those women who did not use loop diuretics.

Our investigation has several limitations that should be mentioned. It included only women who were able to come to the local health care centre and to visit the hospital where the measurements of BMD were performed, that is, only those who were relatively mobile. Another limitation is the cross-sectional design of our study, which does not allow us to examine causal relations. On the other hand, one strength is that our study group can be assumed to be representative of noninstitutionalized women of this age group, since 60% of those invited to participate agreed and, in addition, nearly half of the nonparticipants answered the 'drop-out analysis' questionnaire.

We conclude that elderly women with MNA scores under the median of 27 points, despite having a nutritional status that may be only slightly suboptimal, exhibit an increased risk of osteoporosis. Of the anthropometric measurements, thin mid-arm circumference was a stronger risk factor for having osteoporosis than low body weight. Women with a thin mid-arm circumference under 28 cm had a threefold elevated risk of having osteoporosis. Future prospective studies are needed to further evaluate the causal relations between osteoporosis and nutritional factors.

Acknowledgements

This study was supported financially by grants from the Stockholm County Council and Karolinska Institutet.

References

- Beck AM, Ovesen L, Schroll M (2001). A six months' prospective follow-up of 65 + -y-old patients from general practice classified according to nutritional risk by the Mini Nutritional Assessment. *Eur J Clin Nutr* **55**, 1028–1033.
- Bleda MJ, Bolibar I, Pares R, Salva A (2002). Reliability of the mini nutritional assessment (MNA) in institutionalized elderly people. *J Nutr Health Aging* **6**, 134–137.
- Cederholm T, Hellstrom K (1992). Nutritional status in recently hospitalized and free-living elderly subjects. *Gerontology* **38**, 105–110.
- Cooper C, Atkinson EJ, O'Fallon WM, Melton III LJ (1992). Incidence of clinically diagnosed vertebral fractures: a population-based study in Rochester, Minnesota, 1985–1989. *J Bone Miner Res* **7**, 221–227.
- Cummings SR, Black DM, Nevitt MC, Browner W, Cauley J, Ensrud K *et al.* (1993). Bone density at various sites for prediction of hip fractures. The Study of Osteoporotic Fractures Research Group. *Lancet* **341**, 72–75.
- Dargent-Molina P, Poitiers F, Breart G (2000). In elderly women weight is the best predictor of a very low bone mineral density: evidence from the EPIDOS study. *Osteoporos Int* **11**, 881–888.
- Gerber V, Krieg MA, Cornuz J, Guigoz Y, Burckhardt P (2003). Nutritional status using the Mini Nutritional Assessment questionnaire and its relationship with bone quality in a population of institutionalized elderly women. *J Nutr Health Aging* **7**, 140–145.
- Guigoz Y, Vellas B, Garry PJ (1996). Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. *Nutr Rev* **54**, S59–S65.
- Johann O, Kanis JA, Oden A, Sernbo I, Redlund-Johnell I, Pettersson C *et al.* (2004). Mortality after osteoporotic fractures. *Osteoporos Int* **15**, 38–42.
- Kleinbaum DG, Mitchel K (2002, 1994). *Logistic Regression*. Springer-Verlag: Amsterdam.
- Kullenberg R (2003). Reference database for dual X-ray and laser calscan bone densitometer. *J Clin Densitometry* **6**, 367–371.
- Lofman O, Larsson L, Ross I, Toss G, Berglund K (1997). Bone mineral density in normal Swedish women. *Bone* **20**, 167–174.
- Looker AC, Wahner HW, Dunn WL, Calvo MS, Harris TB, Heyse SP *et al.* (1995). Proximal femur bone mineral levels of US adults. *Osteoporos Int* **5**, 389–409.
- Maaravi Y, Berry EM, Ginsberg G, Cohen A, Stessman J (2000). Nutrition and quality of life in the aged: the Jerusalem 70-year olds longitudinal study. *Aging (Milano)* **12**, 173–179.
- Marshall D, Johnell O, Wedel H (1996). Meta-analysis of how well measures of bone mineral density predict occurrence of osteoporotic fractures. *BMJ* **312**, 1254–1259.
- Persson MD, Brismar KE, Katzarski KS, Nordenstrom J, Cederholm TE (2002). Nutritional status using mini nutritional assessment and subjective global assessment predict mortality in geriatric patients. *J Am Geriatr Soc* **50**, 1996–2002.
- Ponzer S, Tidermark J, Brismar K, Soderqvist A, Cederholm T (1999). Nutritional status, insulin-like growth factor-1 and quality of life in elderly women with hip fractures. *Clin Nutr* **18**, 241–246.
- Saletti A, Johansson L, Yifter-Lindgren E, Wissing U, Osterberg K, Cederholm T (2005). Nutritional status and a 3-year follow-up in elderly receiving support at home. *Gerontology* **51**, 192–198.
- Saletti A, Lindgren EY, Johansson L, Cederholm T (2000). Nutritional status according to mini nutritional assessment in an institutionalized elderly population in Sweden. *Gerontology* **46**, 139–145.
- Salminen H, Saaf M, Ringertz H, Strender LE (2005). Bone mineral density measurement in the calcaneus with DXL: comparison with hip and spine measurements in a cross-sectional study of an elderly female population. *Osteoporos Int* **16**, 541–551.
- Scheirlinckx K, Vellas B, Garry PJ (1999). The MNA score in people who have aged successfully. *Nestle Nutr Workshop Ser Clin Perform Programme* **1**, 61–65. discussion 65–66.
- Siris ES, Miller PD, Barrett-Connor E, Faulkner KG, Wehren LE, Abbott TA *et al.* (2001). Identification and fracture outcomes of undiagnosed low bone mineral density in postmenopausal women: results from the National Osteoporosis Risk Assessment. *JAMA* **286**, 2815–2822.
- Soini H, Routasalo P, Lagstrom H (2004). Characteristics of the Mini-Nutritional Assessment in elderly home-care patients. *Eur J Clin Nutr* **58**, 64–70.
- Thorslund S, Toss G, Nilsson I, von Schenck H, Symreng T, Zetterqvist H (1990). Prevalence of protein-energy malnutrition in a large population of elderly people at home. *Scand J Prim Health Care* **8**, 243–248.
- Valtola A, Honkanen R, Kroger H, Tuppurainen M, Saarikoski S, Alhava E (2002). Lifestyle and other factors predict ankle fractures in perimenopausal women: a population-based prospective cohort study. *Bone* **30**, 238–242.
- Van Nes MC, Herrmann FR, Gold G, Michel JP, Rizzoli R (2001). Does the mini nutritional assessment predict hospitalization outcomes in older people? *Age Ageing* **30**, 221–226.
- Vellas B, Guigoz Y, Baumgartner M, Garry PJ, Lauque S, Albaredo JL (2000). Relationships between nutritional markers and the mini-nutritional assessment in 155 older persons. *J Am Geriatr Soc* **48**, 1300–1309.
- WHO (1994). *Assessment of Fracture Risk and its Application to Screening for Postmenopausal Osteoporosis*. WHO: Geneva.