NUTRITIONAL STATUS USING THE MINI NUTRITIONAL ASSESSMENT QUESTIONNAIRE AND ITS RELATIONSHIP WITH BONE QUALITY IN A POPULATION OF INSTITUTIONALIZED ELDERLY WOMEN

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Abstract: Malnutrition, a risk factor for osteoporotic fractures, is frequent in elderly people and is underdiagnosed and undertreated. There are only few studies on the nutritional status of elderly people in Europe. The Mini Nutritional Assessment (MNA) is a non invasive and validated questionnaire to evaluate nutritional status in elderly people, classified in three groups: 1° score < 17: malnourished, 2° score ≥ 17 and < 24: at risk of malnutrition, 3° score ≥ 24: well-nourished, with a maximum of 30 points. Quantitative ultrasound of bone (QUS) is a method for assessing quality of bone which can be easily performed in nursing homes. Therefore, these two tests allowed to study the relationships between nutritional status and ultrasonic parameters of bone in 78 institutionalized women aged 86 ± 6 years, living in 11 nursing homes around Lausanne (Switzerland). All were assessed by the MNA, had a measurement of the tricipital skin fold and of the grip strength. Functional status was evaluated by the scale "Activity of Daily Living" (ADL), and serum albumin level was measured when permitted. All had QUS of the calcaneus (with an achilles, GE Lunar). The measured parameters are the Broadband Ultrasound Attenuation (BUA), attenuation of a band of ultrasonic frequencies through the medium, expressed in dB/MHz, and the Speed of Sound (SOS), speed of the ultrasounds through the medium, expressed in m/s. A third parameter, the stiffness index (SI), expressed as a percentage of the values obtained by the manufacturer in a young population and derived from BUA and SOS, was calculated automatically: \( SI = (0.67 \times BUA) + (0.28 \times SOS) - 420 \), expressed in percent compared to a young adult population (%YA). Fifteen percent of the women were undernourished and 58% were at risk of malnutrition. As expected, compared with the well-nourished minority, undernourished subjects had significant lower body mass index (BMI), tricipital skin fold (TSF), ADL score and albumin level (p < 0.01). The subjects "at risk of malnutrition" had significant lower BMI, ADL score (p < 0.01), tricipital skin fold and serum albumin (p < 0.05). Ultrasound parameters were low independently of the nutritional status. MNA score correlated significantly with tricipital skin fold (r = 0.508, p < 0.01), ADL (r = 0.538, p < 0.01) and albumin serum level (r = 0.409, p = 0.01). There was a trend for a correlation between the MNA and the ultrasound parameter BUA (r = 0.207, p = 0.07), whereas no correlation was found with SOS and SI. A multivariate analysis showed that tricipital skin fold and ADL explained 61% of the variance of the MNA. In conclusion, using simple and non invasive methods, this study showed that malnutrition and osteoporosis are frequent in institutionalized elderly persons in our country, and the ultrasound parameters are influenced by many other factors in addition to nutrition, especially at this age and in elderly residents of nursing homes.

Key words: Institutionalized, malnutrition, MNA, ADL, aging, osteoporosis, elderly, bone ultrasound, nutrition.

Introduction

More than 40% of the elderly who reach 65 years of age will enter a nursing home and more than half will reside there for at least 1 year (1). In USA, the approximately 190000 nursing homes house about 5% of the elderly population (2).

Malnutrition in elderly is an important public health problem because it increases morbidity and mortality and reduces quality of life (3-5). It remains underdiagnosed and undertreated, partially due to the lack of simple screening tools (6-8). The prevalence of malnutrition in homebound, hospitalized and nursing home elderly reaches levels as high as 30-60% (2,9,10). The prevalence of the protein-energy malnutrition (PEM) varies from one study to another according to the indices chosen for assessment and the arbitrary cut-off points for normal and abnormal anthropometric and biological variables. PEM is considered as a risk factor for osteoporotic fractures for at least two major reasons: 1) The deficiency in calcium and/or protein intake accelerates age dependent bone loss and can induce osteoporosis. 2) Malnutrition increases propensity to fall by impairing coordination and protective mechanisms such as reaction time and muscle strength (11).

Furthermore, up to 75% of elderly patients with fracture of the femoral neck may be considered undernourished (12).

Even with the recent development of simple screening tools (13), systematic evaluation of the risk for malnutrition is still neglected. The aim of this study was to evaluate the nutritional status in a population of institutionalized elderly women, using the MNA and other parameters known to be in relation with the nutritional status, and its relationship with bone quality assessed by bone ultrasound, a transportable and irradiation free technique (14).
Subjects and methods

Eleven nursing homes among 19 major institutions in our geographic area, Lausanne, Switzerland, which were already included in a prospective study on bone ultrasound, agreed to participate at this study. Every women aged ≥ 70 years who where living in these nursing homes could be included. The exclusion criteria were : any specific treatment or drugs (hormonal replacement therapy, bisphosphonates, calcitonin, fluorides, corticosteroids, anticonvulsants), or diseases affecting bone metabolism (primary hyperparathyroidism, osteomalacia, bone metastases) and any severe disease affecting life expectancy. No patient received estrogen replacement therapy at least during the previous 2 years. Some have taken calcium and vitamin D supplements, up to 2 months before the beginning of the study. We finally included in a cross sectional study 78 women aged 86 ± 6 years (mean ± SD) living in 11 nursing homes around Lausanne.

All the women were assessed by the nutritional questionnaire (MNA), had quantitative ultrasound of their right calcaneus (Achilles, Lunar, Madison, WI), and a measurement of their tricipital skin fold and of their grip strength. An evaluation of the functional status by the scale named "Activity of Daily Living" (ADL) was performed. Blood analysis were done in those women who have accepted a venous puncture.

All the women were already included in a trial which assessed the effect of calcium and vitamin D on bone ultrasound (15). They gave their oral consent to perform the questionnaire and the supplementary anthropometric measurements. Informed consent was obtained from family members of the patients with dementia.

Nutritional questionnaire

The MNA is composed of 18 items and involves (8,16) : 1) Anthropometric assessment (body mass index, arm and calf circumference and weight loss). 2) General assessment (6 questions related to lifestyle, medication and mobility). 3) Dietary assessment (8 questions related to number of meals, food and fluid intake, autonomy and feeding). 4) Subjective assessment (4 questions on self-perception of health and nutrition). A person is considered well-nourished with a score≥24, has a risk of malnutrition with a score from 17 to 23.5 and has a malnutrition with a score < 17. All the MNA tests were done by the same investigator, with the collaboration of the nursing homes employees. Because of the high prevalence of cyphoscoliosis of elderly women, the height was assessed by using the formula developed by Guo et al. (17): Height = 67.0 + 2.2 x (height heel-knee) - 0.25 x age. A Mediformal calliper was used to measure heel-knee height.

Quantitative ultrasound of calcaneus

All the women had a measurement of the calcaneus with an Achilles bone ultrasound, which measured the Broadband Ultrasound Attenuation (BUA), attenuation of a band of ultrasonic frequencies, ranging from 200 to 600 kHz, through the medium, expressed in dB/MHz, and the Speed of Sound (SOS), speed of the ultrasounds through the medium, expressed in m/s. A third parameter, the stiffness index (SI), expressed as a percentage of the values obtained by the manufacturer in a young population, derived from BUA and SOS, was calculated automatically : SI = (0.67xBUA) + (0.29xSOS) – 420 (%YA = percentage compared to young adults). This parameter is largely used in clinical practice. Previous studies showed that the ultrasound parameters decrease with age (18,19), discriminate normal to osteoporotic subjects (20) and predict hip fractures (21,22). In the same population of institutionalized women, there was a significant correlation between bone ultrasound and BMI (23). The reproducibility of this method was assessed in a previous study (24) with coefficients of variation of 1.8% for the BUA, of 0.3% for the SOS and of 1.9% for the SI. Quality control was assessed each day of use with a specific phantom. There was no significant variation of the phantom parameters over time.

Grip strength

Grip strength was measured with a Jamar hydraulic dynameter, which is considered to be the most accurate instrument (25). Grip strength has been shown to be a prognostic indicator of the mortality risk in a population of elderly hospitalized women (26) and it is an independent indicator of general bone density (27). Malnutrition can lead to a decrease of muscle's strength (28). The mean of three successive measurements was considered. The standard arm position was used as recommended by the American Society of Hand Therapists: shoulder adducted and neutrally rotated, elbow at 90° flexion and forearm in a neutral position (29).

Tricipital skin fold

Tricipital skin fold (TSF) thickness was measured with a Penflural caliper. The measurement was taken over the midpoint of the arm midway between the tip of the acromion and the olecranon, with the upper arm hanging along the trunk. It is an established and simple anthropometric test (30).

Biochemical measurements

Serum albumin level was measured with standard method (green of bromocresol, Hitachi 917, Roche diagnostic) in a subgroup of subjects.

Activities of Daily Living

We measured health status in terms of function by using the scale named " Activity of Daily Living " (ADL) (31,32). It refers to the abilities needed for independent self-maintenance in the basic functions of bathing, eating, washing, dressing, transferring and walking. The maximal score is 6 (completely dependency for all basic functions) and the minimal is 0 (totally independent person for all basic functions).
**Statistical Analysis**

Statistical analysis were performed with Stata 6.0, Statistical software (Stata Corporation, College Station, Tx, USA). For comparison between independent groups, when discontinued data, Mann-Whitney U-tests were performed, and when continued data, Impaired t-tests were used. To assess the relationship between MNA and anthropometric parameters, bone ultrasound and biochemical markers, a bivariate analysis (Spearman correlation coefficients) was performed first. Since these variables were likely to be correlated, and in order to find the amount of the variability of MNA explained by these parameters, a multiple regression analysis was performed. The differences were considered statistically significant for p values < 0.05. In order to express some results not only in respect to the normal reference values, but also to the distribution of the latters, specific T-scores were calculated. T-score is the difference between the measured value and the mean of the normal reference values divided by the standard deviation of the reference population (women with MNA ≥ 24). This approach allows a precise comparison between different parameters.

**Results**

The mean value (±SD) of the MNA of the 78 studied women was 21 (± 4.1) with a range from 9 to 28 points. The mean values (± SD) of the others parameters are shown in Table 1.

Nine subjects had some difficulties to perform the grip strength, and were excluded for this test. 21 (27%) had a MNA score ≥ than 24, 57 women (73%) had a MNA between 23.5 and 17 (at risk of malnutrition) and 12 of them had a MNA < 17 (malnutrition). Compared to the women with a MNA ≥ 24 (well-nourished), those with MNA between 17 and 23.5 (at risk of malnutrition) had lower : BMI (p < 0.01), ADL score (p < 0.01), tricipital skin fold (p < 0.05), serum albumin levels (p <0.05). Those with MNA < 17 (malnutrition) had lower : BMI (p < 0.01), tricipital skin fold (p < 0.01), ADL score (p < 0.01), serum albumin levels (p <0.01). Age, grip strength, SI and SOS were not significantly different between the three groups of MNA (Table 1).

All the bone ultrasound parameters were low, in all 3 nutritional status groups. For the BUA, the mean value (±SD) was 94.8 ± 10.8 dB/MHz in women with MNA ≥ 24 (58% of the mean of young women (16)), 92.1 ± 8.6 dB/MHz in women with MNA between 17 and 23.5, and 89.8 ± 7.1 dB/MHz in women with MNA < 17.

The bivariate analysis (Table 2) showed a significant correlation between the MNA and the tricipital skinfold (r = 0.508, p < 0.01), ADL (r = 0.538, p < 0.01), albumin serum level (r = 0.409, p = 0.01). The correlation between the MNA and BMI was also high, as expected. There was a trend for a correlation between the MNA and the BUA (r = 0.207, p = 0.07). No correlation was found between MNA and the others measured parameters (SOS, SI, grip strength and age).

### Table 1

<table>
<thead>
<tr>
<th>Characteristics (mean ± SD) of the institutionalized elderly women, according to the Mini Nutritional Assessment (MNA)</th>
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<tr>
<td>Age (years)</td>
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<td>BMI (kg/m2)</td>
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<td>Tricipital skinfold (cm)</td>
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<td>ADL (score)</td>
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<td>SOS (m/s)</td>
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<td>Stiffness (%YA)</td>
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<td>Serum albumin (g/l)</td>
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* p < 0.05, ** p < 0.01, compared to MNA > 24

### Table 2

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<tr>
<th>Bivariate analysis between the different measured parameters (Spearman correlation coefficients). * p &lt; 0.05</th>
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The figure 1 showed all the parameters expressed as T-scores compared with women with MNA ≥ 24, considered as the reference group. T-scores were low for BMI, tricipital skin fold, ADL, and serum albumin, whereas the T-scores were above −0.5 for the three ultrasound parameters, and for the grip strength.

The multiple regression analysis, including the parameters with a significant correlation with the MNA in the bivariate analysis (Tricipital skin fold, ADL and serum albumin), showed that tricipital skin fold and ADL were independent significant predictors of MNA (Intercept (+ 11.86), tricipital skin fold (+ 2.96), ADL (+ 1.30)). 61% of the variability of MNA were explained by this model.

**Figure 1**

Differences between “well-nourished” women (MNA ≥ 24) and women “at risk of malnutrition” or women “malnourished”, expressed in T-scores (number of SD below the mean values obtained in the “well-nourished” group of women) for body mass index (BMI), tricipital skin fold, Activities of Daily Living (ADL), serum albumin, bone ultrasound parameters (BUA, SOS, and SI), and grip strength. In the “malnourished” group of women, the BMI, tricipital skin fold, ADL, and serum albumin were below −1 SD in T-score.

When the MNA was applied to hospitalized or institutionalized elderlies, malnutrition or risk of malnutrition were found in 48 to 54% of the subjects (34,35,36). Since the MNA score is related to mortality (37), it is important to detect malnutrition because a nutritional intervention can decrease morbidity and mortality. For example, a weight gain of 5% decreased mortality in elderly malnourished institutionalized people (38), and dietary supplementation decreased significantly complications and mortality in elderly patients with femoral neck fracture (39,40).

The correlation between the MNA and the tricipital skin fold was high, as expected. Very low values are associated with an increased risk of malnutrition and subsequently of morbidity and mortality (41). There is few data about the tricipital skin fold in aged people in Europe. In a French study on non institutionalized women with a mean age of 82,8 years, the mean value was a little higher (17,1 mm) (42) than in our study, but our population was older (mean age of 86 years) and was institutionalized, which could explain the difference. From the SENeca study (43,44), de Groot et al. showed that tricipital skin fold was higher in females than in males because of the presence of more subcutaneous fat, and that this parameter had only small changes over time.

The mean score of activities of daily living (ADL) was very low, as expected, and was highly correlated with MNA (r = 0.538), in agreement with other reports (r = 0.38) (45), (r = 0.392) (46). This showed that malnutrition and frailty are interdependent.

Serum albumin is frequently used as a biochemical marker of nutrition but its sensibility and its specificity are poor (47).

In our study, the correlation between MNA and albumin level was relatively high (Table 2), as shown in other studies (r = 0.699 (48), r = 0.392 (42)), but not in all. The fall in serum albumin level is a late marker of low nutritional intake (49,50).

The multivariate regression analysis showed that the tricipital skin fold and the ADL score were good predictors of nutritional status in institutionalized elderly people. They explained 61% of the variance of MNA. Albumin was in correlation with MNA in the bivariate analysis, but was not an independent predictor of the MNA, according to the multivariate analysis. Indeed, albumin is highly correlated with ADL, and ADL with MNA. Thereby, albumin is probably a confounded factor.

The assessment of bone health by ultrasound measurements showed only a trend for a correlation between the MNA and the BUA, and no correlation between MNA and SOS or Stiffness. This was due to the fact that all these ultrasound parameters were already very low in these elderly frail people, independently of their nutritional status. The mean BUA of the well-nourished subjects corresponded to only 58% of the mean value of young women. The BUA reflects probably more the prolonged lack of estrogen, vitamin-D deficiency, decreased physical activity and other age-related factors, than the nutritional status. In the same population of institutionalized people...
women, bone ultrasound was correlated BMI (23). To our knowledge, there is no other data using the MNA to evaluate the influence of nutritional status on bone mass.

In the malnourished subjects (MNA < 17), the mean value of BUA, SOS and SI were extremely low, as also shown in another study on institutionalized elders of advanced age (51). The results are below the values for which Sakata and al. (52) showed that the prevalence of hip fracture is increased. These subjects are at very high risk to fracture the hip.

Comparably low values were found in elders with DXA which is the gold standard of bone assessment. Szulc et al. (53) assessed 98 elderly institutionalized French women aged 82 ± 6 years (mean ± SD), and found a mean femoral neck T-score value of -2.7 SD, i.e. below the diagnostic WHO limit of osteoporosis (-2.5 SD) when compared to the NHANES reference population (54). Coin et al. (55) assessed with DXA 30 hospitalized underweight elderly women aged 81 ± 7 years (mean ± SD), who were supposed to be malnourished. He found a mean femoral neck T-score value of -3.1 SD.

These very low values are partially explained by the advanced age of the populations investigated, partially by the fact that they did not benefit from prophylaxis of osteoporosis during their post menopause life, principally with hormonal replacement therapy, and in advanced age with vitamin D and calcium supplementation.

Within this population of very old and institutionalized subjects with many co-morbidities, which influence the MNA more than age does, MNA was not correlated with age.

As expected, grip strength was positively correlated with ADL, but not with MNA. This seems surprising because malnutrition decreases muscle mass and strength. Several factors may explain this apparently contradictory result. The mean grip strength was very low, i.e. at 57% of that of old women (80 years old and more) in good health (25), which strongly restricts the possibility of discovering a correlation. In addition, the examined women had often mental and/or physical impairment and consequently met some difficulties to perform this test. Therefore, grip strength is not a reliable parameter in this particular population.

The limitations of this study rely in the relatively modest number of examined subjects, although comparable to other reports, and in the advanced age of the population, which went along with osteoporosis in almost all subjects, and prevented the detection of correlations between MNA and bone ultrasound.

In conclusion, malnutrition is frequent in institutionalized elderly persons in our country, with 15% of malnourished people and 58% at risk of malnutrition in this study, and is usually underdiagnosed, like elsewhere. The nutritional status, assessed by the MNA, was correlated with the tricipital skin fold, and with the ADL scale. There was only a trend for a correlation with bone health assessed by ultrasound because the latter was almost invariably low in this population, with malnutrition being only one of many pathogenic factors of osteoporosis.

Further studies might illustrate the usefulness of a validated tool for the evaluation of the nutritional status, such as the MNA, in order to permit early nutritional intervention when needed. As recommended by others (56,57), the MNA could be included in the comprehensive geriatric assessment, in order to develop an overall plan for treatment and nutrition, and to decrease morbidity and mortality, although the risk of osteoporotic fractures can not necessarily be influenced.

References


