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Evaluation of nutritional assessment techniques in elderly people newly admitted to municipal care

L Christensson[1]*, M Unosson[1] and A-C Ek[1]

[1]*Department of Medicine and Care, Division of Nursing Science, Faculty of Health Sciences, Linköping University, Linköping, Sweden*

Objectives: To evaluate the Subjective Global Assessment (SGA) and the Mini Nutritional Assessment (MNA) with regard to validity using a combination of anthropometric and serum-protein measurements as standard criteria to assess protein-energy malnutrition (PEM).
Design: Cross-sectional study with consecutive selection of residents aged ≥ 65 y.
Setting: A municipality in the south of Sweden.
Subjects: During a year, starting in October 1996, 148 females and 113 males, aged $\geq 65-104$ y of age, newly admitted to special types of housing for the elderly, were included in the study.
Results: According to SGA, 53% were assessed as malnourished or moderately malnourished on admission. The corresponding figure from MNA was 79% malnourished or at risk of malnutrition. Both tools indicated that anthropometric values and serum proteins were significantly lower in residents classified as being malnourished ($P < 0.05$). Sensitivity in detecting PEM was in SGA 0.93 and in MNA 0.96 and specificity was 0.61 and 0.26, respectively. Using regression analysis, weight index and serum albumin were the best objective nutritional parameters in predicting the SGA- and MNA classifications. Item 'muscle wasting' in SGA and 'self-experienced health status' in MNA showed most predictive power concerning the odds of being assessed as malnourished.
Conclusions: SGA was shown to be the more useful tool in detecting residents with established malnutrition and MNA in detecting residents who need preventive nutritional measures.
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Keywords: nutritional assessment; SGA; MNA; municipal care

Introduction

Malnutrition is a common problem in elderly people newly admitted to hospital (Larsson *et al*, 1990; Cederholm & Hellström, 1992; Muhlethaler *et al*, 1995) or municipal care (Thomas *et al*, 1991; Christensson *et al*, 1999). Many researchers, during the last quarter of the last century, tried to find a valid and reliable tool able to identify elderly people with poor nutritional status or those at high risk of nutritional problems. While no consensus has been reached, many different methods have been used (Omran & Morley, 2000).

The development of malnutrition is described as a continuum, starting with inadequate food intake followed by decreased anthropometrical and biochemical values (Jeejeebhoy *et al*, 1990; Vellas *et al*, 1999). Consequently, anthropometric measures and serum proteins have commonly been used to assess nutritional status in the elderly. However, the measurement of both anthropometric and biochemical values has its shortcomings (Charney, 1995) and the presence of only one parameter has, in some circumstances, low specificity (Jeejeebhoy *et al*, 1990). Anthropometry, which is the core-measurement (de Onis & Habicht, 1996; Lansey *et al*, 1993), is affected by for example, fluid retention and serum proteins by, for example, the function of the liver

*Correspondence: L Christensson, Department of Medicine and Care, Division of Nursing Science, Faculty of Health Sciences, Linköping University, Linköping, Sweden.
E-mail: lennart.christensson@educ.ltjkpg.se
Guarantor: L Christensson.
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(Thuluvath & Triger, 1995), inflammation (Rosenthal *et al*, 1998) and chronic stress (Fleck, 1988; Boosalis *et al*, 1989). When malnutrition has been estimated using a combination of at least one anthropometrical and one biochemical variable, the sensitivity increases (Symreng *et al*, 1983; Lansey *et al*, 1993). Another problem is to determine whether to use the 5th or the 10th percentile as cut-off point for the level of subnormal anthropometrical values (Joosten *et al*, 1999).

As malnutrition in elderly people is associated with impaired activity and general physical condition (Unosson *et al*, 1991), a high prevalence of infections (Michael *et al*, 1991), increased risk of developing pressure sores (Ek *et al*, 1991), reduced mental capacity (Berlinger & Potter, 1991) and increased mortality rate (Larsson *et al*, 1990; Christensson *et al*, 1999), nutritional assessment can also be based on clinical criteria. In order to find a suitable tool for screening for nutritional problems in elderly people, two global assessment tools, the Subjective Global Assessment (SGA) and the Mini Nutritional Assessment (MNA), have been tested.

The SGA evaluates nutritional status and is based on features of the patient's history and physical examination (Detsky *et al*, 1987a). The tool was originally developed for the prediction of nutritionally associated complications in patients undergoing gastrointestinal surgery, but has been used in several different groups of patients as well as in geriatric care. SGA includes questions about weight loss, changes in dietary intake, gastrointestinal symptoms and functional capacity. In the physical examination, subcutaneous tissue loss, muscle emaciation and presence of oedema are examined and subjectively assessed. After the interview and physical examination, the patient is subjectively classified as being: well nourished (SGA A), moderately malnourished (SGA B) or severely malnourished (SGA C). The examiner is recommended to place most emphasis on the features weight loss, poor dietary intake, loss of subcutaneous fat and muscle wasting (Detsky *et al*, 1987a). When seven different techniques of nutritional assessment were evaluated in terms of their ability to predict nutritionally associated complications in surgical patients, the best combination of sensitivity (0.82) and specificity (0.72) was found with SGA (Detsky *et al*, 1984). In another study Detsky *et al* (1987b) showed that surgical patients assessed as SGA C had a likelihood of post-operative complications that was increased seven times. A high degree of interobserver agreement was also found, $\kappa = 0{,}78$ (95% CI 0.62–0.94). The tool has been translated into Swedish and tested for validity and reliability in studies of patients undergoing gastrointestinal surgery (Ulander *et al*, 1993), in geriatric patients (Ek *et al*, 1996) and in elderly patients with hip fractures (Unosson *et al*, 1995).

The MNA has been specifically developed to evaluate the risk of malnutrition in frail elderly people and to identify those who could benefit from early intervention (Guigoz *et al*, 1994). The original version of the tool which has been used in this study contained 18 weighted questions, divided into four nutritional areas including anthropometric measurements (body mass index (BMI), mid upper arm circumference (MAC), calf circumference (CC) and weight loss), a global assessment (six questions related to lifestyle, medication and physical and mental status), a dietary assessment (six questions related to dietary intake and eating problem and a subjective assessment); one question on self-perception of whether food intake is sufficient, and one on self-experienced health status. The responses can give a maximum of 30 points. A score of less than 17 points is regarded as representing malnutrition (MNA 3), 17–23.5 as at risk for malnutrition (MNA 2) and more than 24 points that the elderly person is well nourished (MNA 1; Guigoz *et al*, 1996). For validation, the results of the MNA test have been evaluated against the nutritional assessment performed by two physicians, trained in nutrition, as the gold standard (Guigoz *et al*, 1994). The κ statistic for the MNA total score has been shown to be 0.51 (95% CI 0.28–0.74; Gazzoti *et al*, 1997). The MNA has been found to predict length of hospital stay, costs (Pertoldi *et al*, 1996), and mortality (Beck *et al*, 1999; Comban *et al*, 1999). The tool has been used in elderly Swedish people receiving primary health care (Wissing & Unosson, 1999) and those in home nursing care (Saletti *et al*, 1999).

This paper forms part of a larger study aimed at describing; the frequency of malnutrition in older people newly admitted to municipal care, the characteristics in those assessed as malnourished (Christensson *et al*, 1999) as well as evaluating the effects of nutritional interventions (Christensson *et al*, 2001). The aim of this paper was to evaluate the validity of the SGA and MNA tools in elderly people using a combination of anthropometric and serum protein measurements as standard criteria to define nutritional status.

Methods

Subjects

During a 1 y period, from October 1996 to September 1997, nutritional status was assessed in all residents, aged 65 y or older, who entered special types of housing for the elderly in a municipality in the south of Sweden. During this 1 y period, 315 residents entered municipal care and were invited to participate. Two-hundred and sixty-one were included and 26 did not wish to participate, 13 stayed just a few days and moved on before examination, 14 were determined to be at a terminal stage, and there was one missing value. No significant differences were found between the study group and the non-participants. Fifty-three residents entered service buildings, 124 retirement homes, 77 nursing homes and seven group dwellings for people with dementia-related diseases. One-hundred and thirty-three residents entered municipal care from their own homes, 61 moved from hospital care of more than 1 week duration, and 67 moved from another type of municipal care. In total, 57% were woman with a mean age of 84.8 ± 7.1. In men, the mean age was 82.5 ± 6.4 ($P < 0.05$).

Study procedure

The examination was performed during the resident's first or second week after admission. The procedure started by assessment of nutritional status using SGA and in accordance to the instructions given by the authors (Detsky *et al*, 1987a). Two items were added to the original SGA version: appetite today (good, less good or bad) and food intake today (demonstrated by using pictures of plates with four different portion sizes). After determining the resident as SGA A, B or C the MNA-test was performed (Guigoz *et al*, 1994). A manual describing the meaning of 'psychological stress', 'acute disease', 'severe dementia or depression', 'mild dementia' and 'full meals' was used. In residents with reduced mental capacity, a caregiver or a proxy who knew the resident well answered some of the questions.

The procedure was completed by examining objective nutritional parameters including height, body weight, MAC, triceps skinfold thickness (TSF), arm muscle circumference (AMC), serum albumin and serum transthyretin. The resident's height was estimated in a supine position on a flat bed using equipment with a fixed foot-plate and an adjustable head-plate. Mechanical balance chairs were used to measure the resident's body weight except for residents admitted to service buildings, where an electronic portable bathroom scale was used. Body weight was measured to the nearest 0.1 kg. The mechanical chairs and the bathroom scale were checked for accuracy twice during the study period using a standard weight. Weight index (WI) in percent was calculated from actual weight divided by the reference weight×100. The reference weight for women was 0.65×height (cm) − 40.4 (kg), and for men, 0.80×height (cm) − 62 (kg) (Bengtsson *et al*, 1981; Warnold & Lundholm, 1984). In order to validate WI, BMI (kg/m^2) was used. The correlation coefficient between WI and BMI was 0.97 ($P<0.001$). MAC was measured with a tape measure and TSF with a Harpenden skinfold calliper at the midpoint of the arm between the tips of the acromion process and the olecranon process. The mean of three measurements was used. The non-dominant arm was measured unless the arm was paralysed or otherwise injured. AMC was calculated as AMC = MAC − 0.1 (Π×TSF). Reference values for TSF and AMC were related to age and sex and the 10th percentile was considered as being a subnormal value (Symreng, 1982). Serum albumin and transthyretin were measured using Rate Nephelometry, Beckman Array and local reference values were used where mean − 2 s.d. (<36 g/l) for serum albumin and for transthyretin (<0.23 g/l) represented subnormal values.

A resident was assessed as being protein-energy malnourished (PEM) if two or more of the nutritional parameters were subnormal, including at least one anthropometric and one biochemical measurement (Symreng, 1982; Table 1).

The nutritional assessments were performed in the residents' rooms and by one of the authors (L Ch). The study was approved by the Research Ethics Committee, Faculty of Health Sciences, Linköping University, Sweden.

Table 1 Reference values for objective nutritional variables and criteria for defining protein-energy malnutrition. In TSF and AMC the 10th percentile represents the cut-off level and for serum proteins the mean-2 s.d.

	Women	*Men*
Anthropometry		
Weight index (%)	<80	<80
TSF (mm)		
65–69 y	≤16	≤7
70–79 y	≤13	≤6
80–89 y	≤10	≤6
≥90 y	≤7	≤4
AMC (cm)		
65–69 y	≤19	≤23
70–79 y	≤19	≤22
80–89 y	≤18	≤21
≥90	≤17	≤20
Serum proteins		
Albumin (g/l)	<36	<36
Transthyretin (g/l)	<0.23	<0.23

TSF, triceps skinfold thickness; AMC, arm muscle circumference.

Statistics

Descriptive statistics such as mean, standard deviation and percentage were used. Differences between groups were determined using chi-square test, Fisher's exact test, Kruskal–Wallis test and one-way ANOVA variance analysis with Bonferroni test and were considered to be statistically significant at the $P<0.05$ level.

Criterion validity was estimated in three different ways. (a) The relationships between objective nutritional parameters and SGA and MNA classification are described as the percentage of residents with subnormal nutritional values. (b) Sensitivity, specificity and diagnostic predictivity were estimated when SGA A and MNA 1, representing well nutrition, as well as SGA B + C and MNA 2 + 3, representing malnutrition, were tested against PEM/non-PEM. In order to separate MNA 'well nourished' from 'malnourished', the optimal MNA cut-off point was investigated using Receiver Operating Characteristic (ROC) curves. Index D′ described the area under the curve (Steiner & Norman, 1995). (c) In order to study the power of the objective nutritional parameters for prediction of the dichotomized SGA and MNA classifications, multiple logistic regression forward stepwise analysis (Wald) was used.

Regarding construct validity, the SGA and MNA items (independent variables), were, in turn, tested against the dichotomized classification (dependent variable), using multiple logistic regression forward stepwise analysis (Wald). In these analyses, the alternative answers for each item in SGA were transformed into a scale where 0 represented low risk of malnutrition and 1, 2, 3 or 4 an increased risk of malnutrition. In the items 'muscle wasting' and 'loss of subcutaneous fat', 0 represented no loss and 3 severe loss. A resident with no 'diseases affecting nutritional status' scored 0, if yes, disease affecting nutritional status was present, he or she scored 1. Good 'appetite today' scored 0 and bad appetite 2.

In 'functional capacity' 0 represents no dysfunction and 2 severe dysfunction. In the item 'portion size' 1 represented a big portion and 4 a small portion. SGA items 'weight loss' and 'weight change in the past 2 weeks' were excluded because of missing data, 44 and 82%, respectively. In the multiple logistic regression analysis all items were considered as continuous variables. The statistical program used was SPSS 10.1.

Results

According to SGA, 29% of the residents were classified as moderately malnourished (SGA B) and 24% as severely malnourished (SGA C). The corresponding figures in MNA were 56% at risk of malnutrition (MNA 2) and 23% as malnourished (MNA 3; Table 2). There were no significant differences between the classes, with regard to age and gender, irrespective of method.

Criterion validity

Mean values of anthropometric and serum protein measurements were significantly lower in residents classified as SGA C as compared to those classified as SGA A and B except for AMC in men. In MNA, the same pattern was seen (Tables 3 and 4). Significantly more anthropometrical values and serum proteins below reference limits were seen in residents classified as malnourished as compared to well-nourished (Table 5). Two percent of the SGA A-residents were below the reference value for bodyweight compared to 67% in SGA C. In MNA 1, no resident was below reference value as compared to 55% in MNA 3. For serum albumin, 50% of the residents in SGA A and 49% in MNA 1 were below the reference limit as compared to 77% in SGA C and 78% in MNA 3. Mortality rate 6 months after admission was significantly higher in residents classified as malnourished as compared to well-nourished (Table 5).

Fifty-seven (22%) residents were below reference limits in three or more of the objective nutritional parameters (Table 6). Of these, 67% were classified as SGA C and 55% as MNA 3. The mean (of a maximum of five) nutritional values below reference limits was 1.0 ± 0.1 in SGA A, 1.7 ± 0.1 in SGA B and 3.1 ± 0.2 in SGA C ($P < 0.001$). In MNA 1, the mean number was 1.0 ± 0.1, 1.5 ± 0.1 in MNA 2 and 2.9 ± 0.2 in MNA 3 ($P < 0.001$).

In 49 residents, none of the objective nutritional values were below reference limits. Of these residents, 40 were classified as SGA A and nine as B (Table 6). In the nine SGA B-residents, WI and AMC were lower, $93.6\% \pm 7.2\%$ and 23.1 ± 2.2 cm respectively, as compared to $104.4 \pm 12.2\%$ ($P < 0.05$) and 24.8 ± 1.9 cm ($P < 0.05$), respectively, in the 40 SGA A-residents. These nine SGA B-residents also scored higher risk of malnutrition in the items 'diseases affecting nutritional status', 'loss of subcutaneous fat', 'muscle wasting' and 'decreased functional capacity' ($P < 0.05$). According to MNA, 16 of the 49 residents were classified as MNA 1 and the remaining 33 as MNA 2 (Table 6). The MNA 2-residents

Table 2 Equivalence between classification of nutritional status using Subjective Global Assessment (SGA) and Mini Nutritional Assessment (MNA)

	SGA class			
MNA class	*A*	*B*	*C*	*Total*
1	50	3	1	54
2	71	59	17	147
3	2	14	44	60
	123	76	62	261

SGA A, well-nourished; SGA B, moderately malnourished; SGA C, severely malnourished. MNA 1, well-nourished; MNA 2, at risk of malnutrition; MNA 3, malnourished.

Table 3 SGA class, anthropometry and serum proteins in 261 residents on admission to municipal care

	SGA A (n = 123) Mean ± s.d.	*SGA B (n = 76) Mean ± s.d.*	*SGA C (n = 62) Mean ± s.d.*
Anthropometry			
Weight index (%)	103.7 ± 14.8	$92.0 \pm 12.7^{*A}$	$75.8 \pm 11.9^{*AB}$
TSF (mm)			
female	16.0 ± 4.2	$12.3 \pm 3.6^{*A}$	$9.2 \pm 3.8^{*AB}$
male	10.6 ± 3.4	$7.8 \pm 2.7^{*A}$	$6.5 \pm 2.1^{*A}$
AMC (cm)			
female	23.3 ± 2.2	$22.3 \pm 2.1^{*A}$	$18.8 \pm 2.1^{*AB}$
male	24.9 ± 2.3	23.8 ± 2.3	$20.7 \pm 1.9^{*AB}$
Serum proteins			
Transthyretin	0.24 ± 0.06^{a}	0.22 ± 0.06	$0.19 \pm 0.06^{*AB}$
Albumin (g/l)	35.0 ± 5.0^{a}	34.0 ± 5.0	$31.0 \pm 6.0^{*AB}$

SGA A, subjective global assessment well-nourished; SGA B, moderately malnourished; SGA C, severely malnourished.
One-way analysis of variance with Bonferroni test with significance level 0.05.
*[A]Significant different from SGA A; *[AB]significantly different from SGA A and B.
[a]Three missing values.

Table 4 MNA class, anthropometry and serum proteins in 261 residents on admission to municipal care

	MNA 1 (n = 54) Mean ± s.d.	*MNA 2 (n = 147) Mean ± s.d.*	*MNA 3 (n = 60) Mean ± s.d.*
Anthropometry			
Weight index (%)	104.2 ± 15	$95.9 \pm 15.5^{*1}$	$79.3 \pm 14.5^{*1,2}$
TSF (mm)			
female	16.1 ± 4.1	$13.5 \pm 4.5^{*1}$	$9.4 \pm 3.5^{*1,2}$
male	10.4 ± 3.9	9.3 ± 3.3	$7.4 \pm 2.8^{*1}$
AMC (cm)			
female	23.1 ± 2.5	22.2 ± 2.5	$19.7 \pm 2.8^{*1,2}$
male	24.7 ± 2.6	24.2 ± 2.4	$21.7 \pm 2.8^{*1,2}$
Serum proteins			
Transthyretin (g/l)	0.24 ± 0.06^{a}	0.23 ± 0.06^{b}	$0.19 \pm 0.05^{*1,2}$
Albumin (g/l)	35.8 ± 4.5^{a}	34.5 ± 5.0^{b}	$30.2 \pm 5.6^{*1,2}$

MNA 1, mini nutritional assessment well-nourished; MNA 2, at risk of malnutrition; MNA 3, malnourished.
One-way analysis of variance with Bonferroni test with significance level 0.05.
*[1]Significant different from MNA 1; *[1,2]significantly different from MNA 1 and 2.
[a]One missing value; [b]two missing values.

Table 5 Percentage of newly admitted residents with subnormal anthropometry, serum proteins and frequency of mortality[a] in different SGA and MNA classifications ($n = 261$)

		SGA classification			*MNA classification*		
Nutritional parameters	*References value*	*A* (n = *123*) %	*B* (n = *76*) %	*C* (n = *62*) %	*1* (n = *54*) %	*2* (n = *147*) %	*3* (n = *60*) %
Anthropometry							
BMI	< 20	2	14	67***	0	15	55***
Weight index	< 80%	2	14	66***	0	14	55***
TSF	≤ 10th percentile	4	30	59***	7	20	47***
AMC	≤ 10th percentile	2	4	42***	4	6	35***
Serum proteins							
Albumin	< 36 g/l	50[d]	63	77**	49[b]	58[c]	78**
Transthyretin	< 0.23 g/l	47[d]	60	66**	43[b]	53[c]	72**
Mortality	≤ 6 month	15	24	37**	11	20	40**

SGA, subjective global assessment; A, well-nourished; B, moderatley malnourished; C, severely malnourished; MNA, mini nutritional assessment; 1, well-nourished; 2, at risk of malnutrition; 3, malnourished. BMI, body mass index, AMC, arm muscle circumference, TSF, triceps skinfold.
[a]Six months after the nutritional assessment, [b]one missing value; [c]two missing values; [d]three missing values.
Kruskal Wallis test, $^{**}P < 0.01$; $^{***}P < 0.001$.

Table 6 Percentage of residents with and without subnormal nutritional values[a] in total group and in relation to SGA and MNA classifications

		SGA classification			*MNA classification*		
Number of subnormal values	*Total group* (n = *261*) %	*A* (n = *123*) %	*B* (n = *76*) %	*C* (n = *62*) %	*1* (n = *54*) %	*2* (n = *147*) %	*3* (n = *60*) %
0	19	33[d]	13		30[b]	23[c]	
1	29	35	30	16	44	29	15
2	30	31	34	23	24	31	32
3	10	1	19	15		11	15
4	8		3	31	2	4	23
5	4		1	15		2	15
	100%	100%	100%	100%	100%	100%	100%

SGA, subjective global assessment; A, well-nourished; B, moderately malnourished; C, severely malnourished; MNA, mini nutritional assessment; 1, well-nourished; 2, at risk of malnutrition; 3, malnourished.
[a]Table 1; [b]one missing value; [c]two missing values; [d]three missing values.

scored higher risk in the MNA item 'mobility', 'dementia/depression', 'mode of feeding' and 'self-experienced health status' as compared to MNA 1-residents ($P < 0.05$), but no differences were seen in the objective nutritional parameters.

According to criteria used to define protein-energy malnutrition (PEM; Table 1), 26% of the residents were assessed as PEM. When the classifications were dichotomized, agreement between SGA and PEM/non-PEM was seen in 181 residents (69%) and between MNA and PEM/non-PEM in 116 (44%). Sensitivity of SGA was 0.93, specificity 0.61 and diagnostic predictivity 0.47. Corresponding figures for MNA were 0.96, 0.26 and 0.31, respectively. The optimal cut-off point in MNA in order to detect PEM was established at MNA-score < 20 (D′ 0.74). Using the optimal cut-off point, total agreement with PEM/non-PEM was seen in 188 residents (72%). The sensitivity decreased to 0.76, specificity increased to 0.70 and diagnostic predictivity increased to 0.48.

Using the 5th percentile in TSF and AMC, instead of the 10th, three PEM residents should have been assessed as non-PEM. With the 5th percentile, the sensitivity of SGA increased 1% and specificity decreased 1%. Similar changes were seen in MNA.

According to the multiple logistic regression forward stepwise analysis, WI was the objective nutritional parameter which best predicted the dichotomized classification in both tools. Odds ratio (OR) in SGA was 0.91, $P < 0.000$, 95% confidence interval (CI) 0.88–0.93 and in MNA OR 0.95, $P < 0.000$, CI 0.94–0.98. The second best predictor was serum albumin in SGA OR 0.90 ($P < 0.002$, CI 0.85–0.96) and also in MNA OR 0.90 ($P < 0.003$, CI 0.84–0.97).

Construct validity
In 153 of the residents (59%), the SGA classifications showed complete agreement with those of the MNA. Of the residents assessed as being SGA C, 71% were concurrently assessed as being MNA 3. Most discrepancy was seen in the classification MNA 2. Among 130 residents classified as MNA 2, 71 were classified as SGA A and 59 as SGA B. With all SGA items included in the multiple logistic regression forward stepwise analysis, six proved to be significantly associated to the classification. The item 'muscle wasting' showed most predictive power (Table 7). The overall rate of correct classification of the dependent variable (predicted outcome compared with the observed outcome) was estimated as 92.7%. In MNA, nine questions were significantly associated, where the question 'self-experienced health status' showed most predictive power (Table 8). The overall rate of correct classification was estimated as 95.7%.

Discussion
The population studied comprised elderly people admitted to municipal care during a 1 y period. Both SGA and MNA could be used on all residents despite heterogeneity with regard to age, illness, medical treatment and functional capacity. The study showed that the frequency of malnutrition in residents newly admitted to municipal care was high, irrespective of the method the nutritional assessment was based on. The frequency of malnutrition ranged from 21 (MNA 3) to 26% (PEM) and moderately malnourished or risk of malnutrition from 29 (SGA B) to 56% (MNA 2).

The objective nutritional parameters clearly differentiate between residents classified as malnourished and those classified as well nourished (Tables 3 and 4). Even though some residents with subnormal nutritional values were classified as SGA A and MNA 1, the number of subnormal values was significantly greater in SGA C and MNA 3 residents (Table 5). One percent of the residents classified as SGA A had three or more subnormal nutritional values as compared to 61% in SGA C residents. In MNA 1 residents, 2% had three or more subnormal values as compared to 53% in MNA 3 (Table 6).

Mean values in SGA C and MNA 3 residents were below the reference levels in all objective nutritional parameters except TSF in men. As a decrease in fat stores is described as a long-term process (Charney, 1995) significant and measurable changes may not yet have appeared at the time of admission.

Using objective nutritional parameters as standard criteria, SGA and MNA showed very good ability (sensitivity) to identify residents assessed as PEM. The transformation

Table 7 Multiple logistic regression analyses for components of the SGA: prediction of SGA class (SGA A regarded as well-nourished and SGA B + C as malnourished)

Items	*Points on the scale*[a]	*Step*	*OR*	*Significent*[b]	*95% CI*
Muscle wasting	0–3	1	6.02	0.000	2.90–12.46
Diseases affecting nutritional status	0–1	2	6.99	0.000	2.44–20.80
Loss of subcutaneous fat	0–3	3	10.44	0.000	4.26–25.54
Appetite today	0–2	4	3.12	0.006	1.39–6.98
Functional capacity	0–2	5	1.82	0.007	1.18–2.86
Portion size	1–4	6	2.54	0.031	1.08–6.25

SGA, subjective global assessment; A, well-nourished; B, moderately malnourished; C, severely malnourished. OR, odds ratio; CI confidence interval
[a]High points indicate increased risk of malnutrition. [b]Multiple logistic regression forward stepwise (Wald).

Table 8 Multiple logistic regression analyses for components of the MNA: prediction of MNA class (MNA 1 regarded as well-nourished and MNA 2 + 3 as malnourished)

Items	*Points on the scale*[a]	*Step*	*OR*	*Significance*[b]	*95% CI*
Self-experienced health status[c]	4	1	0.12	0.000	0.04–0.38
Mobility	3	2	0.03	0.000	0.01–0.15
Body mass index (kg/m^2)	4	3	0.08	0.000	0.02–0.29
Fruit and vegetable intake[d]	2	4	0.02	0.004	0.001–0.29
Weight loss during last 3 months	4	5	0.08	0.000	0.024–0.24
Number of prescribed drugs[e]	2	6	0.03	0.001	0.004–0.22
Nutritional problems[f]	3	7	0.006	0.000	0.000–0.09
Number of full meals/day	3	8	0.017	0.005	0.001–0.29
Psychological stress or acute disease[g]	2	9	0.14	0.023	0.02–0.76

MNA, mini nutritional assessment; 1, well-nourished; 2, at risk of malnutrition; 3, malnourished. OR, odds ratio; CI, confidence interval.
[a]Low points indicate increased risk of malnutrition. [b]Multiple logistic regression forward stepwise (Wald). [c]The resident's view in comparison with other people of the same age; [d]does or does not consume two or more servings of fruits or vegetables/day; [e]does or does not take more than three prescription drugs/day; [f]viewed by the resident themselves; [g]in the past 3 months.

from the originally three SGA/MNA classes into two was probably the main cause of low specificity (ie correctly classifying those without malnutrition). While the number of residents assessed as MNA 2 is higher (56%) than SGA B (29%), the specificity of MNA becomes lower, as does the diagnostic predictivity. Low specificity means that many residents with false-positive diagnoses of malnutrition might withdraw resources from those in real need of nutritional measures. When a tool with low specificity is used it is most important that the disease/illness in focus commonly occurs in the population, otherwise too many false positive diagnoses will be made. Low specificity, as found in this study, might indicate that SGA and MNA reflect poor health as well as nutritional status. SGA was originally developed for prediction of nutritionally associated complications but it is suggested that this tool may be equally likely to represent an index of sickness rather than nutrition (Jeejeebhoy *et al*, 1990). The World Health Organization (WHO) has stated that there is a large body of evidence to suggest that malnutrition is strictly related to health (de Onis & Habicht, 1996). As a high frequency of malnutrition in this group is well known, high sensitivity is the most important character of nutritional screening instruments (Dempsey & Mullen, 1987) like SGA and MNA. The pattern of sensitivity, specificity and diagnostic predictivity in this study corresponds with that of an earlier study including elderly people in hospital care, where SGA was tested against objective nutritional criteria similar to those used in this study. It was also shown that a trained SGA examiner was required if high sensitivity and specificity were to be attained (Ek *et al*, 1996). To be competent in nutritional assessment, a training period is proposed (Detsky *et al*, 1994). In a healthy elderly population, MNA has shown high sensitivity in identifying at-risk individuals using body weight loss (0.96) or a low BMI (0.97) as standard (de Groot *et al*, 1998). In agreement with this study, specificity was low.

WI was shown, in the multiple logistic regression analysis, to be the best nutritional parameter for prediction of the SGA and MNA classifications. When WI decreased by 1%, the odds of being classified as SGA and MNA malnourished increased 1.1 times and 1.05 times respectively. WI as the main significant factor of the SGA classification is in accordance with earlier studies (Ek *et al*, 1996).

In both tools, serum albumin was the second best predictor. When serum albumin decreased by 1 g/l, the odds of being classified as malnourished increased 1.1 times in both tools. Serum albumin as an indicator of malnutrition is criticized (Rosenthal *et al*, 1998), but the results show that serum albumin was significantly associated with the classifications. Severe hypoalbuminaemia is shown to be a strong predictor of mortality (Ferguson *et al*, 1993). In this study, the SGA and MNA-classifications were found to be significantly related to mortality (Table 5).

Besides mortality, low serum albumin is also described as a general indicator of health status in hospitalized elderly patients (Ferguson *et al*, 1993). SGA and MNA contain items reflecting diseases affecting nutritional status. In developing MNA, serum albumin was used to stipulate the scoring levels (Guigoz *et al*, 1994). This might have effected the strong relation between the MNA-classifications and the item ‘self experienced health status’ (Table 8).

For construct validity, multiple logistic regression forward stepwise analysis was used and showed that the main emphasis in SGA was on anthropometry and the presence of diseases relevant to nutritional status (Table 7). This is in agreement with the instructions which place focus on the variables; weight loss, poor dietary intake, loss of subcutaneous tissue and muscle wasting (Detsky *et al*, 1987a). The most powerful item in MNA focused on how the residents experienced health status and managed life, expressed as ability to walk, weight loss and food intake (Table 8). Subsequently, MNA has been restructured into a two-step screening strategy where the items with the highest sensitivity and overall accuracy were selected for an initial screening, the MNA-SF, followed by administration of the full MNA to people defined as being potentially at risk by the MNA-SF (Rubenstein *et al*, 1999). Items included in the MNA-SF are; ‘declined food intake over the past 3 months’, ‘weight loss during last 3 months’, ‘mobility’, ‘psychological stress or acute disease in the past 3 months’, ‘neuropsychological problems’ and BMI. In this study, four out of these six items where shown, in the multiple logistic regression analysis, to be significantly associated with the classification.

The SGA commenced the nutritional assessment procedure in this study because it is based on a subjective classification. The intention was to eliminate the influence from MNA and from the objective nutritional parameters. After the SGA classification had been determined, the MNA test was performed. As MNA consists of predetermined answers, it was suggested that the assessment could not be influenced by SGA. The examination was completed by conducting the anthropometric measurements and by taking blood samples.

Even though serum proteins were significantly lower in residents classified as malnourished, approximately half of the residents who were classified as well-nourished also had values below the reference levels (Table 5). It is well known that serum proteins (Fleck, 1988; Boosalis *et al*, 1989; Rosenthal *et al*, 1998) and anthropomerty (Gibson, 1990; de Onis & Habicht, 1996; Thuluvath & Triger, 1995) are affected by other factors in addition to nutritional status. To minimize these influences on the objective assessment, two or more parameters below reference values were used, including one anthropometrical parameter and one serum protein measurement. In TSF and AMC, when the 5th percentile was used instead of the 10th, rather small differences were seen. The intention of the chosen definition was to facilitate identification of residents on the borderline between being well nourished and malnourished.

When the correlation among the independent variables is low, each variable has the ability to contribute something unique to the prediction of the dependent variable (Steiner

& Norman, 1995). Some of the SGA and MNA items are supposed to be highly correlated. However, the logistic regression analyses showed that six SGA and nine MNA items had unique information adding powerfully to the classification.

Answers to the SGA and MNA items could, in all residents, be obtained either from the resident him- or herself, their relatives, the staff or from the nursing records. However it was not possible to estimate weight loss, which is an important component in both SGA and MNA, in 44% of the residents because of missing values before admission. This is in agreement with other studies (Cederholm & Hellström, 1992; Saletti *et al*, 1999). In the MNA construction, questions with missing values do receive weighted points and consequently influence the classification. In order to incorporate all residents, including elderly people with reduced mental capacity, a care giver or a proxy who knew the resident well had to answer some of the questions. This management has been recommended by Vellas *et al* (1999). To use a person who is well informed about the situation is in accordance with everyday practice and has been shown to be reliable (Ostbye *et al*, 1997).

The questions and the physical examination in SGA focus on the period prior to admission. Muscle wasting, diseases affecting nutritional status, loss of subcutaneous fat and reduced functional capacity (Table 7) are results of a former ongoing process. When a resident is classified as moderately malnourished, loss of fat and muscle is established and measurable. The relation between the anthropometrical measures and the nutritional classification seemed to be stronger in SGA as compared to MNA. In TSF and AMC, more significant differences were seen between the SGA classes than between those in MNA (Tables 3 and 4). SGA showed better ability to classify non-PEM residents with decreased WI and AMC as 'moderately malnourished' than MNA did in classifying these same residents as 'at risk of malnutrition'. Consequently, when the standard criteria include anthropometrical parameters, the diagnostic predictivity becomes higher in SGA as compared to MNA. As sensitivity in detecting PEM was dependent on established physical signs of malnutrition, the clinical implication is that SGA is not a useful tool for its early detection as these signs occur late in the process.

MNA has, in contrast to SGA, been developed especially for the elderly. Some of the questions focus to a higher extent on the present period, such as type of dwelling, quality of dietary intake, presence of sores, ability to eat and transfer and how the residents consider themselves according to nutritional problems and health status. When the resident's ability to manage daily life is reduced, MNA seems to classify the resident as 'at risk of malnutrition'. As there are cultural differences influencing items such as 'number of prescribed drugs', 'independent living' and in the meaning of 'full meals', this study indicates that the cut-off point between MNA 1 and 2 could be adjusted to the individual country where the instrument is applied.

Irrespective of whether the resident is classified as malnourished or as being at risk, nutritional attention is needed. According to SGA, every other newly admitted residents in this study was in need of this attention while according to MNA, the figure is four residents out of five. The choice of SGA or MNA will depend upon whether the nutritional assessment is aiming at prevention or treatment.

Conclusions

The study has demonstrated that both SGA and MNA were found to have criterion-related validity and to be useful in a Swedish elderly population with regard to nutritional assessment. Using PEM/non-PEM as criterion standard, SGA and MNA showed high sensitivity. WI was the objective nutritional parameter best able to predict the classifications. The item with most predictive power in the classification was 'muscle wasting' in SGA and 'self-experienced health status' in MNA. SGA is most useful in detecting malnourished residents and MNA in identifying residents who need preventive measures.

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