Introdution

Elderly people are at-risk subjects as regards to their nutritional status. This is due to numerous co-existing factors in this age-group, among which cognitive and mobility alterations, comorbidity, use and abuse of drugs and social and economic determinants play a major role (1, 2).

The prevalence of malnutrition reaches the highest values among hospitalized elderly people and among institutionalized older adults, conditions in which malnutrition affects up to 60 - 85% of all subjects (3, 4).

In geriatric settings the use of validated nutritional screening tools becomes crucial, especially that these tools be fast and easy to apply. Malnutrition in the elderly is combined with increased morbidity, hospitalization and mortality (5-7).

The Mini Nutritional Assessment (MNA) is one of the most applied tools to evaluate nutritional status in older adults, even in institutionalized elderly subjects, because it can identify the presence of malnutrition or risk for malnutrition in order to take corrective and/or preventive measures (3, 8). The various items that make up the MNA questionnaire investigate different components of the nutritional status, including anthropometric measures, eating habits, general and subjective health of older adults.

Most studies have examined the results of the total MNA score, while only a few have focused on the analysis of the results obtained in single items or in specific sections of the tool (4).

A further instrument for routine evaluation of body composition, widely applied in geriatric populations, is the BIA (Bioelectrical Impedance Analysis), which is the measure of the impedance by cells to the flow of an electric current, especially in its vectorial interpretation called BIVA (Bioelectrical Impedance Vector Analysis) (9-12).

Some previous studies compared the MNA scores with the values of body masses derived from the conventional BIA (13, 14), while only a few studies investigated this comparison using the BIVA (15, 16). This study aims at assessing the presence and the level of malnutrition in elderly institutionalized people through Mini Nutritional Assessment scores and to observe if the bioelectrical impedance vector changes in relation to nutritional status.

Materials and methods

The sample of enrolled persons consisted of 463 guests from twelve nursing homes placed in Florence (Italy), all aged 65 yrs or over. Each enrolled person agreed to participate and signed an informed consent document.

The age of the sample (355 women and 108 men) varies between 65 and 101 yrs (mean age 83.8 ± 8.0 SD). Women, representing more than 3/4 of the sample, have a higher mean age than men: 84.6 ± 7.7 SD vs 80.9 ± 8.2 SD.

We analyzed the nutritional status through different diagnostic tools and indicators:
- Bioelectrical Impedance Analysis (BIA);
- Mini Nutritional Assessment (MNA);
- Anthropometric measures (weight, height, mid-upper arm, calf, waist and hip circumferences);
- Blood sample for the determination of biohumoral markers linked to malnutrition;
- Anamnestic questionnaire.

In this paper we show the results of the nutritional status assessment through BIVA and MNA.

**Bioelectrical Impedance Analysis**

The bioelectrical parameters of resistance (R) and reactance (Xc) expressed in ohm were obtained by means of a single frequency impedance analyzer using an operating frequency of 50 kHz at 800 μA (Soft Tissue Analyzer, ® Akern S.r.l.). The accuracy was checked with a calibration circuit of known impedance (R = 380 ohm, Xc = 47 ohm, 1% error).

Whole body impedance measurements were taken by using the standard positions of outer and inner electrodes on the right hand and foot (tetrapolar technique). The procedure was performed according to the guidelines of the National Institutes of Health Technology Assessment Conference Statement (17).

The values of R and Xc were normalized for height to avoid conductor length effect. These standardized values were interpreted according to BIVA in the two forms of tolerance and confidence.

The position on the R/Xc graph of Z vector referred to a single subject compared to the three gender-specific, reference ellipses (corresponding to 50%, 75% and 95% of the distribution of the values in the general population - BIVAtolerance) allows for a qualitative and semi-quantitative assessment of the body composition; the phase angle, calculated as arctan (Xc/R), is positively related to body cell mass and the length of the vector is inversely related to body water (9, 25).

The reference ellipses used here are those for the Italian population (15 - 85 yrs) (18).

Through BIVAtolerance analysis we compared different groups of subjects defined by the mean impedance vector and 95% confidence ellipse.

**Mini Nutritional Assessment**

MNA is a tool for assessing nutritional status composed of 18 items, which can be grouped in four sections:

- Anthropometric assessment (Body Mass Index, mid-upper arm and calf circumferences, weight loss);
- Global assessment (mobility, number of medicinal drugs taken, pressure sores and skin ulcers, recent acute pathological events, independence);
- Dietary assessment (number of daily meals, solid and liquid food intake, ability to eat without help, appetite reduction);
- Subjective assessment (self-perceived health and nutritional status).

The total MNA score is obtained by adding the scores assigned to any single item.

The subjects are then classified in three nutritional categories according to their scores: well-fed when MNA≥23.5, at risk of malnutrition if 17≤MNA<23.5, malnourished when MNA<17.

**Statistical analysis**

The resulting measurements and the subjects’ personal data were recorded in an electronic database and analyzed with SPSS 17.0.

BIVA was carried out through BIA vector® nomograms; the differences among the mean impedance vectors in different MNA classes were assessed by using T2 Hotelling’s test (19).

The mean scores of malnourished, at-risk and well-fed subjects obtained in the four MNA sections were compared by using Kruskal-Wallis’ test.

Through Spearman’s test, we correlated (p<0.05) the total MNA score and single-item scores.

**Results**

The selected sample consists of 463 institutionalized elderly people aged 65 yrs or over. Women represented 77% with a mean age of 84.6 years, nearly four years older than men.

Approximately 12% of the sample had been living in a nursing home for over seven years, and 43% for less than two years. For sixteen subjects (3.5% of the sample) it could not be established when they arrived at the nursing home, even after having interviewed members of the assistance staff.

As regards to BIVAtolerance, 30.4% of the female subsample and 25.9% of the male one were distributed outside the 95% tolerance ellipse, filling up, in almost all cases, the area to the right of the ellipse major axis, indicating a condition

**Table 1**

<table>
<thead>
<tr>
<th>MNA</th>
<th>Anthropometric Mean</th>
<th>95% CI</th>
<th>Global Assessment Mean</th>
<th>95% CI</th>
<th>Dietary Assessment Mean</th>
<th>95% CI</th>
<th>Subjective Assessment Mean</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maligned (n = 104)</td>
<td>3.89*</td>
<td>3.56 – 4.23</td>
<td>2.45*</td>
<td>2.19 – 2.71</td>
<td>5.79*</td>
<td>5.54 – 6.03</td>
<td>1.51*</td>
<td>1.39 – 1.64</td>
</tr>
<tr>
<td>Well-nourished (n = 89)</td>
<td>7.73*</td>
<td>7.62 – 7.87</td>
<td>5.63*</td>
<td>5.42 – 5.84</td>
<td>8.61*</td>
<td>8.53 – 8.70</td>
<td>3.35*</td>
<td>3.23 – 3.48</td>
</tr>
</tbody>
</table>
of impaired nutritional status.

On the basis of MNA global score, 23.1% (n = 82) of the women’s subgroup and 20.4% (n = 22) of the males are malnourished (MNA < 17), while 60.0% (n = 213) and 52.8% (n = 57), respectively, are at risk of malnutrition (17 ≤ MNA ≤ 23.5) and only 16.9% (n = 60) and 26.8% (n = 29) are well nourished (MNA > 23.5).

Stratifying the results for each section of the MNA (anthropometric, global assessment, dietary assessment and subjective assessment), we found a statistically significant difference (p<0.001) in the mean scores obtained in the three subgroups indicating well-nourished, at-risk and malnourished conditions (Table 1).

Analysis of the correlation between the MNA global score and single-item scores show that 16 out of 18 items have a significant correlation (p<0.05). The items not significantly related to the MNA global score were those concerning independence at home and number of medicinal drugs taken (Table 2).

Table 2

<table>
<thead>
<tr>
<th>MNA item</th>
<th>Spearman’s r</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode of feeding</td>
<td>0.635</td>
<td>*</td>
</tr>
<tr>
<td>Self view of nutritional status</td>
<td>0.622</td>
<td>*</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>0.586</td>
<td>*</td>
</tr>
<tr>
<td>Calf circumference</td>
<td>0.564</td>
<td>*</td>
</tr>
<tr>
<td>Food intake declined</td>
<td>0.544</td>
<td>*</td>
</tr>
<tr>
<td>Self view of health status</td>
<td>0.527</td>
<td>*</td>
</tr>
<tr>
<td>Neuropsychological problems</td>
<td>0.513</td>
<td>*</td>
</tr>
<tr>
<td>Mobility</td>
<td>0.508</td>
<td>*</td>
</tr>
<tr>
<td>Weight loss during the last 3 months</td>
<td>0.498</td>
<td>*</td>
</tr>
<tr>
<td>Mid-arm circumference</td>
<td>0.419</td>
<td>*</td>
</tr>
<tr>
<td>Psychological stress/acute disease</td>
<td>0.354</td>
<td>*</td>
</tr>
<tr>
<td>Number of meals eaten per day</td>
<td>0.325</td>
<td>*</td>
</tr>
<tr>
<td>Pressure sores/skin ulcers</td>
<td>0.191</td>
<td>*</td>
</tr>
<tr>
<td>Intake of fruit/vegetables per day</td>
<td>0.149</td>
<td>*</td>
</tr>
<tr>
<td>Intake of drinks per day</td>
<td>0.142</td>
<td>*</td>
</tr>
<tr>
<td>Protein intake</td>
<td>0.110</td>
<td>*</td>
</tr>
<tr>
<td>Independence</td>
<td>0.056</td>
<td>0.227</td>
</tr>
<tr>
<td>Number of drugs taken</td>
<td>-0.210</td>
<td>0.645</td>
</tr>
</tbody>
</table>

Plotting the subjects divided into the three MNA scores on BIVAtolerance chart (Figure 1), we can see that in both genders the decrease of the score seems to be related to an increase in the proportion of subjects placed outside the 95% confidence ellipse (Table 3).

Moreover, in women the differences among the three groups are also highly significant (Hotelling’s T² test), as evidenced in the BIVAtolerance graph in which the three 95% ellipses do not overlap (Figure 2). In men, BIVAtolerance analysis shows a lower phase angle for subjects whose MNA score was less than 17; however, the three ellipses are overlapped, which means no statistically significant differences since the scarce number of male subjects in the sample. Phase angle is larger in men than in women (4.5 ± 1.1 and 4.1 ± 1.1 degrees, respectively). A comparison of phase angle by gender and MNA score shows that the values in Malnourished subjects (MNA<17) are 3.7 ± 1.0 and 4.3 ± 1.1 degrees, in At risk (17 ≤ MNA ≤ 23.5) are 4.2 ± 1.1 and 4.5 ± 1.1 degrees and in Wellnourished (MNA > 23.5) are 4.4 ± 1.0 and 4.6 ± 1.2 degrees in women and men respectively.
BIOELECTRICAL IMPEDANCE VECTOR ANALYSIS AND MINI NUTRITIONAL ASSESSMENT

Discussion

According to the MNA results, more than 80% of our sample are malnourished or at risk for malnutrition. The combined prevalence of malnutrition and risk for malnutrition ranks at the top values as compared to similar studies carried out using the MNA, which recorded, in institutionalized elderly individuals, ranges between 93% (20) and 73.5% (21). For instance, a comparison with a different setting, namely elderly receiving home-care services, recorded values which are, on average, lower than the above cited (51%) (22).

In our sample, the percentages of elderly people at risk for malnutrition (MNA 17-23.5) or malnourished (MNA < 17) were 58.3% and 22.5%, respectively. The proportion of subjects at risk does not much differ from the one obtained in recent studies carried out in European (23) and Italian (24) populations; in the latter case, however, a very low percentage of malnourished elderly people were taken (5.1%). The variability of the proportion of subjects with different nutritional status in long term care settings, as reported in national and international literature, may be partly explained by the heterogeneity of the guests’ characteristics, and that the percentage of elderly subjects with risk factors for malnutrition can greatly differ within different structures. Therefore, the elderly of our sample seem to be a highly vulnerable group regarding nutrition.

The significant differences found among the three subgroups – malnourished, at-risk and well-fed – in the mean scores obtained in the four MNA areas indicate that poor nutritional status is linked to the deterioration of all investigated aspects (anthropometric, global, dietetic and subjective assessment). A recent study (22) found that malnourished, at-risk and well-fed subjects did not differ significantly in the items referred to subjective assessment; this discrepancy with the results of our study could be attributed to the different settings in which the study was carried out, because the sample included home-care elderly individuals.

BIA is characterized by ease of use, non-invasive, low cost, portability in any context (with the possibility of carrying out the examination bed-side) and safety. However, in the conventional interpretation the equations for the estimation of body compartments can lead, particularly in the elderly, to substantial prediction errors; moreover, the equations must be verified for various disease states (9). BIVA provides information about body composition (body cell mass, hydration status) independently from weight measurement or equation inherent errors (25).

BIVAtolerance analysis indicated that, in our sample, the distribution of the elderly differed from that observed in a study on Sardinian healthy elderly people (12), in which 95.1% of women and 98.9% of men were placed within the 95% confidence ellipse, reflecting the distribution of the reference population. Specifically, in the sample we assessed that BIVAtolerance indicates the presence of compromised nutritional status in a higher percentage of elderly people (25.9% of males and 30.4% of females were outside the 95% confidence ellipse).

This result could be due to a highly compromised health – comorbidity – frequently assessed in subjects recovered in nursing homes; moreover, institutionalization represents in itself a risk as regards to malnutrition (for instance, because of loneliness, negligence in checking food assumption and body weight).

The results obtained by the comparison between BIA assessment and MNA assessment indicate that malnutrition, diagnosed with MNA, is strongly associated with significant changes in bioelectrical impedance (R and Xc). As such, a phase angle variation is recorded in the three groups that differ in the MNA scoring. Specifically, a lower score is associated with a decreased phase angle of the mean vector, reflecting a reduction of body cell mass. A similar migration of the mean vector are reported in a research carried out in free-living elderly subjects (15) though, in our sample, the values of phase angle of the three groups with different MNA score are smaller and similar to those recorded in experiences carried on in institutionalization (16).

Conclusions

The nutritional status of elderly nursing home residents is frequently compromised. An assessment of nutritional status should first be carried out at admission, in order to have a baseline, and then in a continuous perspective monitoring.

It could be useful to combine “traditional” tools of nutritional assessment like the MNA with BIVA analysis. BIA is easy to use and non-invasive and these qualities make it applicable to heavily compromised elderly people, even when cognitively or physically impaired.

BIVA analysis may make a contribution both in the nutritional assessment of each subject and in epidemiological investigations on groups at risk, so as to represent a useful tool for effective public health interventions.

References


19. Piccoli A and Pastori G (2002); BIVA Software. Padova, Italy: Department of Medical and Surgical Sciences, University of Padova.


25. Piccoli A, Rossi B, Pillon L, Bucciante G. A new method for monitoring body fluid...