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Nutritional Parameters, Body Composition, and Progression of Disability in Older Disabled Residents Living in Nursing Homes

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Background. The evaluation of nutritional status is one of the primary components of multidimensional geriatric assessment. We investigated the relationship between some markers of malnutrition and the modifications in functional status in a sample of older disabled residents living in nursing homes.

Methods. Ninety-eight subjects who were independent in at least two activities of daily living (ADLs) were enrolled in a 2-year longitudinal study. Anthropometric, nutritional, and metabolic parameters, as well as body composition, were measured at baseline and after 2 years.

Results. Deteriorating functional status (≥2 additional lost ADLs) was associated with baseline albumin levels (Tertile 3 vs Tertile 1; odds ratio [OR] 0.16, 95% confidence interval [CI] 0.04–0.67) and subscapular skinfold thickness (Tertile 3 vs Tertile 1; OR 0.06, 95% CI 0.006–0.50). After multivariate adjustment, the OR for increasing disability was >4 in subjects with decreasing body cell mass (BCM), compared with subjects with a stable BCM. The degree of BCM reduction was strongly related to the number of additional ADLs lost at follow-up (test for trend, $p = .003$).

Conclusions. In a sample of older disabled nursing home residents, signs of malnutrition seem to predict further worsening in functional status. Furthermore, BCM declines proportionally to the loss in ADLs, suggesting the existence of a strong relationship between BCM loss and the progressive deterioration of functional status.

THE evaluation of nutritional status is one of the primary components of multidimensional geriatric assessment (1,2). Indeed, it has been reported that 30% to 60% of older subjects living in nursing homes are malnourished (3,4); for example, Abbasi and Rudman (5) found that 30% to 50% of elderly nursing home residents had substandard body weight and midarm circumference and low albumin concentrations. Involuntary weight loss and geriatric cachexia have been associated with poor health outcomes, such as morbidity and mortality (6,7), and malnutrition has been associated with considerable dysfunction and disability (7,8).

Disability in activities of daily living (ADLs) is mainly a dynamic and progressive process that is the consequence of the interaction of chronic diseases and age-related physiological changes (9). It is an important risk factor for institutionalization, recurrent hospitalization, falls, and acute illnesses in older subjects (9).

In a large sample of older nursing home residents (the Istituto di Riposo per Anziani [IRA] study), we recently found that severe disability was associated with some indicators of malnutrition. By multivariate analysis, we demonstrated that this association was strong and independent from the effects of age, gender, and comorbidity (10). Nevertheless, we could not establish any temporal relationship between malnutrition and disability, owing to the cross-sectional design of the survey.

We here report the results of the 2-year follow-up of the IRA study. The aim of this longitudinal research was to examine the relationship between some markers of malnutrition, including body cell mass (BCM), measured by tetrapolar bioelectric impedance analysis (BIA), and the modifications in functional status over a period of 2 years. In this study, we specifically focused our interest on the association between nutritional status and the risk of further decline in physical function in a sample of functionally impaired older subjects. Although many factors have been associated with disability (9), much less is known about the trajectory of disability in institutionalized older subjects.

Methods

The IRA is a nursing home located in Padua, Northern Italy. The IRA study is a longitudinal study with the aim of evaluating the relationship between a large number of biological parameters, functional status, and mortality. Functional status was assessed at baseline and after 2 years. Findings from the baseline cross-sectional survey have been reported elsewhere (10).

Subjects

From a total population of 410 individuals living in the nursing home at the time of the study's inception, 344 established residents (272 women and 72 men) were enrolled in the IRA study. Inclusion criteria were as follows: subjects must (i) have been ≥65 years old; (ii) have resided at the Institute for at least 2 months; and (iii) have had no clinical evidence of acute illness at the time of observation, nor in the previous 30 days. Terminal patients with cancer or severe liver and kidney disease were excluded.

At baseline, 172 subjects dependent in all or all but one ADL (Katz classes F and G) were considered fully disabled and were excluded. The remaining 172 subjects were independent in at least two ADLs (Katz classes A to E) and were considered at risk for worsening disability during the 2-year follow-up period. Among these subjects, 52 died within the 2-year follow-up period. We defined a priori the presence of worsening disability as a loss of two or more ADLs during this 2-year follow-up period. According to this definition, survivors were classified into two groups: group 1, 40 individuals with stable or improved functional status as defined by their Katz score; group 2, 58 individuals with a significant functional decline, defined as the loss of two or more ADLs at follow-up.

At baseline, there were two individuals without disability (no lost ADLs) in group 1 and six in group 2. Twenty-two subjects who lost only one ADL at follow-up were not considered for this specific analysis.

Anthropometric Parameters

According to standardized methods, weight, height, tricipital and subscapular skinfold thickness, and waist and hip circumference were measured by the same physician, who was unaware of the subjects' Katz score (11). The subjects' body mass index (BMI, kg/m^2) and waist/hip ratio (WHR) were calculated. A Holtain caliper (Holtain, Ltd., Crymych, UK) was used to quantify skinfold thickness. Body composition was determined by tetrapolar BIA (12,13) using a BIA 109 instrument (RJL Systems, Detroit, MI). The BIA measurements were carried out after a 20-minute rest period. The electrodes were placed just proximal to the right metacarpal and third metacarpal joints, and between the right medial and lateral right malleoli. A current at 50 Hz was then introduced.

Clinical Chemistry Parameters

All analyses were performed in the central laboratory of the Geriatric Hospital of Padua, which complies with a quality-control program. Blood samples were obtained in the morning after a 12-hour overnight fast, kept at 4°C for 1 hour, and then centrifuged at 3000 rpm for 10 minutes at 4°C to obtain serum or plasma. Serum total protein and iron were measured by spectrophotometry, while albumin and transferrin were assayed by nephelometry. Cell blood counts were evaluated using a Bayer-H600 (Bayer, Tarrytown, NY) instrument. Total cholesterol and triglycerides were assayed by the Trinder method. HDL cholesterol (HDL-C) was determined after precipitation of apo B–containing lipoproteins with $MgCl_2$-phosphotungstic acid (in 84 of 98 subjects).

Health and Functional Status

Age, gender, number of chronic medical conditions, and drugs currently used were recorded at baseline. The ADLs were evaluated at baseline by the geriatricians working in the nursing home. The subjects were classified by the Katz index (14) in reference to their progressive dependence in feeding, continence, moving about, going to the toilet, dressing, and bathing. The same physicians evaluated the ADLs again after 24 months. Chronic medical conditions (heart disease [including coronary heart disease and heart failure], hypertension, stroke, diabetes mellitus, claudication, chronic obstructive pulmonary disease, parkinsonism, rheumatic disease, depression, and dementia) were ascertained by both medical examination and chart review.

Statistical Analysis

All results are reported as mean ± standard deviation. Baseline characteristics of participants were compared according to functional status at the 2-years follow-up by using unpaired (paired when reported) Student's *t* test for continuous variables and the χ^2 test or Fischer's Exact Test (when necessary) for categorical variables. The association of single variables with the 2-year modifications in ADLs (worsening vs constant/improved) was evaluated by univariate logistic regression analysis; afterwards, multivariate logistic regression analysis was used to identify the variables independently associated with worsening functional status. Variables were selected by the stepwise forward selection method. The probability of the variable entering or being removed from the model was .05 and .10, respectively.

The following baseline parameters were forced into the model: albumin, transferrin, total cholesterol, subscapular skinfold thickness, and WHR (tertiles), age, gender, and number of drugs (Tertile 1: ≤2 drugs; Tertile 2: >2 and ≤5 drugs; Tertile 3: >5 drugs). The baseline Katz status (classes 0 to 6) was also included into the model to adjust for the initial level of disability.

To investigate the association between the longitudinal change in selected characteristics and the likelihood of becoming disabled in two or more additional functions, we compared the average absolute change in these variables between the two groups of subjects by using the unpaired *t* test. The 2-year absolute modification in the variables of interest (Δ) was calculated by subtracting the baseline value from the 2-year value (Δ = 2-y value − baseline value). The association of the dichotomized 2-year modification in BCM (decreased vs stable/increased BCM) with increasing disability (≥2 ADLs lost) was evaluated by multivariate logistic regression analysis. Systat (Systat, Inc., Evanston, IL) for Windows, version 5.0, and SPSS for Windows, version 7.0 (SPSS, Inc, Chicago, IL) statistical packages were used.

Results

The baseline characteristics of the sample divided by the 2-year modifications in ADLs are reported in Table 1. Subjects with deteriorating functional status at the 2-year follow-up were older and had been treated with a higher number of drugs. On average, the number of lost ADLs was 1.6 and 2.0 in groups 1 and 2, respectively ($p = .34$); after 2 years, lost ADLs were 1.4 in group 1 and 5.0 in group 2 ($p =$

Table 1. Principle Characteristics of Disabled Nursing Home Residents

Baseline Variables	Group 1 (2-y ADLs constant or improved)	Group 2 (≥2-y ADLs worsened)	*p* Value†
Gender, % female	74%	85%	.18
Age (yr)	79.8 ± 7.8	82.7 ± 6.6	.05
No. Chronic Diseases	3.0 ± 1.3	3.4 ± 1.3	.35
No. Drugs			
Baseline	2.9 ± 1.7	4.2 ± 2.3	.01
After 2 y	3.4 ± 1.8	4.4 ± 2.3	.03
No. Lost ADLs			
Baseline	1.6 ± 0.9	2.0 ± 1.1	.34
After 2 y	1.4 ± 0.9	5.0 ± 1.0	.001‡
Albumin (g/dl)	4.48 ± 0.4	4.27 ± 0.35	.01
Transferrin (mg/dl)	260 ± 59	228 ± 38	.003
Total Cholesterol (mg/dl)	226 ± 42	205 ± 43	.03
HDL-C (mg/dl)	51.2 ± 17	44.8 ± 11.5	.04
Hemoglobin (g/dl)	13.9 ± 1.3	13.1 ± 1.3	.009
SST (mm)	15.8 ± 4.9	12.9 ± 5.5	.01
WHR	0.97 ± 0.1	0.91 ± 0.1	.01
BMI (kg/m^2)	26.9 ± 3.9	25.1 ± 4.6	.07
BCM (kg)	17.9 ± 5.2	15.9 ± 3.5	.05

Note: Only subjects independent in ≥2 activities of daily living (ADLs) at baseline were included in this study. HDL-C = high density lipoprotein cholesterol; SST = subscapular skinfold thickness, WHR = waist/hip ratio, BMI = body mass index, BCM = body cell mass.

†Group 1 vs group 2, unpaired *t* test.

‡Group 1 vs group 2 (unpaired *t* test) and group 2 baseline vs after 2 years (paired *t* test).

.001 for group 1 vs group 2, and group 2 baseline vs 2-y follow-up). Group 2 patients were also characterized by lower albumin, transferrin, total cholesterol, HDL-C, hemoglobin, WHR, subscapular skinfold thickness, BMI, and BCM.

The principal diseases in the two groups of subjects at baseline are reported in Table 2. No significant differences emerged, but the prevalence of cognitive impairment was much higher in group 2 (32%) compared with group 1 (13%).

Table 3 reports the results of multivariate logistic regression analysis for the 2-year modification in ADLs. Deteriorating functional status (≥2 ADLs lost) was associated with

Table 2. Principal Baseline Diseases in Disabled Nursing Home Residents Divided by 2-year Modification in Functional Status

Disease	Group 1 (2-y ADLs constant or improved, %)	Group 1 (≥2-y ADLs worsened, %)	*p* Value
Dementia	20	19	.80
Cognitive impairment	13	32	.11
Parkinson's disease	6	15	.45
Depression	23	13	.36
Cerebrovascular disease	22	24	.70
Heart failure	13	15	.89
Coronary heart disease	23	11	.45
Hypertension	30	19	.35
Diabetes	13	9.5	.80
Neoplasm	10	4	.65
COPD	10	18	.50

Note: COPD = chronic obstructive pulmonary disease; ADLs = activities of daily living.

Table 3. Results of Logistic Regression Analysis (Stepwise Forward) of 2-year Modifications in Functional Status (Stable/Improved ADLs vs ≥2 Worsened ADLs)

Variable	β	*SE*	Wald Test	Odds Ratio	95% CI
Albumin					
Tertile 1				Reference	
Tertile 2	− .011	0.82	0.0002	0.97	0.19–4.91
Tertile 3	− 1.79	0.71	6.27	0.16	0.04–0.67
SST					
Tertile 1				Reference	
Tertile 2	− 1.73	1.10	2.45	0.17	0.02–1.5
Tertile 3	− 2.86	1.08	6.99	0.06	0.006–0.5
No. Drugs					
≤ 2				Reference	
2–5	2.02	0.77	6.82	7.5	1.65–34.2
> 5	2.36	0.89	7.03	10.5	1.85–61.4
Gender, male	− 1.47	0.74	3.97	0.22	0.054–0.97

Notes: Logistic model: albumin, transferrin, total cholesterol, subscapular skinfold thickness, waist/hip ratio, age, gender, number of drugs, baseline Katz status. ADLs = activities of daily living; CI = confidence interval; SST = subscapular skinfold thickness.

serum albumin levels, subscapular skinfold thickness, number of drugs, and female gender. The results did not change by forcing BCM, BCM to fat-free mass ratio, or BCM to weight ratio into the model (data not shown).

The 2-year modifications in the principal clinical-chemistry and anthropometric parameters are reported in Table 4. A slight reduction in all parameters was observed at the 2-year follow-up. The BCM decreased, on average, by 0.1 kg (from 17.8 to 17.7 kg, or −0.5%) in group 1, and by 2.4 kg (from 15.9 to 13.1 kg, or −15%) in group 2 ($p < .01$). The odds ratio for increasing disability in subjects with decreasing BCM was 4.94 (95% confidence interval [CI] 1.17–20.21) compared with subjects with stable and/or increased BCM, after adjustment for the principal baseline variables (i.e., Katz score, BCM, albumin, total cholesterol, serum iron, number of chronic medical conditions, and number of drugs), age, and gender. In a different model, the odds ratio was 5.60 (95% CI 1.03–30.11), after adjustment for base-

Table 4. Two-year Average Modifications (Δ = 2-y value − baseline value) in the Principal Clinical-Chemistry and Anthropometric Parameters

Variables (Δ)	Group 1 (2-y ADLs constant or improved)	Group 2 (≥2-y ADLs worsened)	*p* Value†
Albumin (g/dl)	−0.61	−0.67	.35
Transferrin (mg/dl)	−22	−29	.57
Total cholesterol (mg/dl)	−19	−16	.36
HDL-C (mg/dl)	+0.76	−1.12	.24
Hemaglobin (g/dl)	−0.53	−0.90	.46
SST (mm)	−1.5	−4.0	.43
WHR	−0.04	−0.08	.09
BMI (kg/m^2)	−1.1	−2.1	.08
BCM (kg)	−0.1	−2.4	.01

Note: ADLs = activities of daily living; HDL-C = high density lipoprotein cholesterol; SST = subscapular skinfold thickness; WHR = waist/hip ratio; BMI = body mass index; BCM = body cell mass.

†Unpaired *t* test.

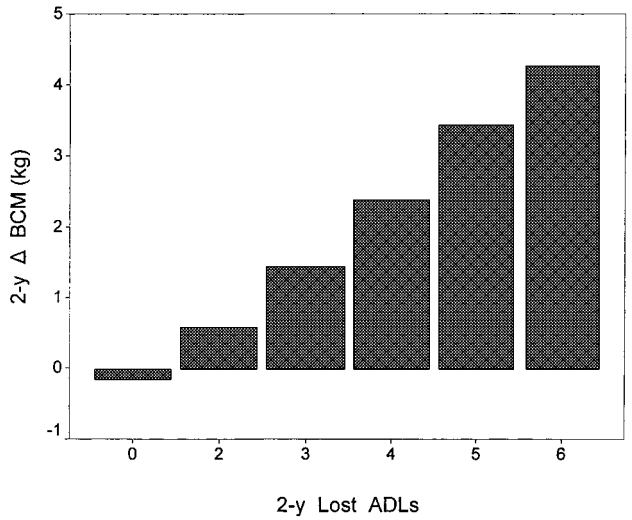

Figure 1. Two-year body cell mass (BCM) modification (Δ BCM: 2-y value − baseline value). Subjects were divided into six groups based on the number of additional activities of daily living (ADLs) lost at follow-up (0–5 ADLs lost). Test for linear trend was ascertained from the linear regression model with the number of ADLs lost entered as an ordinal variable.

line Katz score, age, gender, and the 2-year changes (Δ) in albumin, cholesterol, serum iron, hemoglobin, HDL-C, transferrin, and number of drugs.

Figure 1 shows a stepwise dose-response relationship between the 2-year BCM reduction and the 2-year decline in functional status; the degree of BCM reduction was strongly related to the number of additional ADLs lost at the follow-up (test for trend, $p = .003$).

Discussion

We found that older disabled nursing home residents with 2-year deteriorating functional status were characterized, at baseline, by a "worse" nutritional status when compared with disabled subjects with stable and/or improved ADLs. Even if the two groups were very similar in gender distribution, number of chronic diseases, and functional status, group 2 subjects had lower values in several laboratory (e.g., albumin, transferrin, and cholesterol) and anthropometric (e.g., BCM, skinfold thickness, and WHR) parameters compared with group 1. Among the variables considered, low albumin and subscapular skinfold thickness values (Tertile 1) were associated with the risk of deteriorating functional status after multivariate adjustment.

We also measured the BCM, which is considered the "working" portion of fat-free mass, by means of BIA. This is important, as the term "malnutrition" refers to the loss of structural body components, which is most accurately reflected by a reduction in the BCM (15). Not only was the BCM lower at baseline in group 2 compared with group 1, but it was also the only variable that decreased significantly at the same time as functional status. After multivariate adjustment, the risk of increasing disability was about fivefold in subjects who lost BCM compared with individuals with stable and/or increased BCM. Furthermore, the reduction in BCM was proportional to the number of ADLs lost at follow-up.

Taken together, our results suggest the following: (i) at baseline, several indicators of malnutrition were lower in subjects who experienced a further decline in functional status compared with those who remained stable over the 2-year follow-up period; (ii) low albumin and subscapular skinfold thickness values seem to predict future worsening in functional status; and (iii) the loss in BCM and the loss of physical function are significantly associated over time.

It is not known why markers of malnutrition and disability may be associated in older nursing home residents, nor is the possible mechanism linking the loss in BCM and physical function known. Low albumin levels are considered a marker of malnutrition and have been associated with poor outcomes, such as morbidity and mortality (16,17). Albumin is also a negative protein of the acute phase (18), and it has been proposed that low albumin might be a marker for disease in elderly individuals (19). Of interest, Baumgartner and colleagues (20) found that serum albumin was associated with muscle mass and suggested that the increased risk of disability with low albumin levels in elderly persons might reflect an association with sarcopenia.

The loss of BCM is a good indicator of malnutrition (15). A reduction in BCM has been associated with chronic systemic inflammation in patients with rheumatoid arthritis and cancer (21–23), and a role of inflammatory cytokines has been proposed in the pathogenesis of geriatric cachexia (24). Cederholm and colleagues (25) found increased interleukin 6 (IL-6) and IL-1β levels in older subjects with cachexia but without any evidence of malignant or infectious diseases. On the other hand, it has been shown that disability is associated with increased levels of plasma IL-6 in elderly persons (26), and Ferrucci and colleagues (27) found that higher IL-6 levels predict disability onset in community-dwelling older persons.

It is difficult to explain the relationship between markers of malnutrition, in particular the loss in BCM, and disability. One possible explanation is that the loss in BCM, possibly driven by chronic inflammation, might lead to a loss in physical function, perhaps through a loss in muscular strength. This would be in accord with the cross-sectional results of Zamboni and colleagues (28) who found, in a sample of elderly women, an association between BCM and leg strength, suggesting a possible role of muscle mass loss as a risk factor for disability. Nevertheless, basal BCM was not an independent predictor of increasing disability in our sample, although it is well known that low muscular strength is a predictor of future disability. A second possibility is that deteriorating functional status might lead to a decrease in BCM through undernutrition or inactivity. This is not supported by the observation that most of the subjects in group 2 were able to feed themselves independently. Furthermore, BCM was lower at baseline in group 2 compared with group 1, despite a very similar functional status. Another possibility is that a third factor might cause the decrease in both physical function and BMC. It is possible that older residents with deteriorating functional status, unlike those with stable ADLs, would be frail or "more frail." If this is the case, chronic diseases and the respective chronic inflammation state would lead to weight loss, undernutrition, and disability in these subjects; this would be consis-

tent with both their baseline characteristics and their progressive loss in BCM and ADLs. The dose-response relationship between the number of medications and the risk of functional decline seems to reinforce the main role of symptomatic diseases in the disablement process.

Finally, three limitations of the present study must be underlined. First, our sample was made by a relatively small number of older disabled nursing home residents. Not only do the results need to be confirmed in larger samples, but they also cannot be generalized to community-dwelling older individuals. Second, we measured indirectly BCM by BIA, and it is possible that age, sex, and other factors, including hydration, could have led to over- or underestimation of body compartments. Nevertheless, all the individuals were clinically stable and had no evidence of acute illness at the time of measurements. Furthermore, terminal patients with cancer or severe liver and kidney disease were excluded. On the other hand, BIA is currently used to estimate malnutrition in elderly individuals (28) and has been correlated with other traditional methods, both in healthy subjects and in patients with different diseases and nutritional status (13,29,30). Third, we did not consider the new incidental pathologies, which possibly appeared during the follow-up. It is possible that, at least in some cases, a new disease might have caused a sudden worsening in functional status with a consequent reduction in BCM.

In conclusion, the results of this longitudinal study suggest that (i) signs of malnutrition seem to predict the worsening in functional status in older disabled nursing home residents and (ii) the BCM declines proportionally to the loss in ADLs over time, suggesting the existence of a strong relationship between BCM loss and the deterioration of functional status in institutionalized older individuals. Nevertheless, the underlying mechanism for such an association has not been determined. Understanding whether the decline in BCM is causally related to the decline of physical function might provide important insight into the pathophysiology of disability in older persons.

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