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Prognostic value of muscle mass assessed by DEXA in elderly hospitalized patients

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SUMMARY

Objectives: To analyze the prognostic value of lean mass measured by DEXA and to compare it with lean muscle mass assessed by anthropometrics, calf circumference, subjective assessment and with physical muscle function tests in elderly hospitalized patients.

Methods: We study 187 hospitalized patients aged ≥65 years. We assessed nutrition by anthropometrics, mid arm muscle area, triceps skinfold and calf circumference, by subjective nutritional assessment and by DEXA, lean and fat mass and bone mineral density (BMD); muscle function by handgrip strength, gait speed, standing balance and stand-up test; disability and activities of daily living and the clinical frailty score; and comorbidity by Charlson index. Outcomes were assessed by mortality at 100 days and long-term follow up.

Results: Male sex showed higher comorbidity and mortality although females were older, with decreased muscle mass and function, disabled and frailer. Long term mortality was also related to decreased lean mass evaluated by subjective assessment, midarm anthropometry, calf circumference and DEXA (appendicular lean and fat mass and BMD); muscle function impairment assessed by gait speed, standing balance and stand-up test; frailty; disability and comorbidity. Variables with long term independent predictive value were comorbidity, inability to perform any of the muscle function tests: gait speed, standing balance and stand-up; subjective nutritional score, appendicular lean mass under the 10th percentile and male sex.

Conclusions: Females are older and frailer but with lower comorbidity; they showed a better survival. The best predictive mortality factor was comorbidity, but DEXA appendicular lean mass under the 10th percentile showed an independent and high predictive value on mortality.

1. Introduction

In recent decades as life expectancy has increased, the number of high-comorbidity elderly patients admitted to general medical wards is higher. Malnutrition with muscle loss, impaired physical function, frailty and disability are frequent among elderly patients [1–3].

Decreased muscle mass has been defined by very different methods: midarm muscle area (MAMA) [1,2,4,5] calf circumference [6], subjective nutritional assessment [1,2,7] computed tomography (CT), and appendicular lean mass determined by bioimpedance or dual energy X ray absorptiometry (DEXA), the latter two being the more qualified methods [3,8]. However, these two methods require a device and training, therefore they are not available for all population use in comparison to the other methods reported that are perhaps more inaccurate but easier

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and inexpensive. The use of DEXA has been questioned because of its cost [5].

It is not clear if the prognosis of elderly patients depends more on muscle mass or impaired muscle function, and if the prognostic value is independent. There are studies that report that muscle physical function tests are better prognostic indicators than muscle mass [9–12]. Also, in many studies the assessment of the decline of the elderly is based on the decline of functional muscle tests such as hand grip strength (HGS), gait speed, standing balance and stand up tests [13,14].

Malnutrition assessment in the elderly by methods of limited availability and high cost may be questionable. So, our aim is to compare the prognostic value for mortality of lean mass assessed by DEXA with muscle mass evaluated by subjective assessment, MAMA or calf circumference and with physical function tests such as hand grip strength, gait speed, standing balance, stand up tests, frailty and disability in elderly hospitalized patients, adjusting by sex and comorbidity.

2. Methods

We performed a prospective observational study including 187 patients (January 2014–August 2016) of 65 years or older who were consecutively admitted to the Internal Medicine Department of the Hospital Universitario de Canarias and followed up until October 2018; we studied 106 men and 81 women aged 65–94 years. Patients must have been admitted for an acute illness or decompensation via the emergency room. We excluded terminal patients (with a life expectancy of less than six months) and patients with acute delirium or impaired consciousness that persisted at the second day of hospital admission. We also excluded 120 patients that were incompletely studied because DEXA was not performed because of severity of illness or inability to cooperate. The endpoint of the study was short and long-term mortality; patients were followed-up until October 2018. Sixteen patients (8.6%) died 100 days after admission and 89 (47.6%) died in the long-term. Diseases were categorized and recorded according to the diagnoses in medical reports. Charlson's comorbidity index (without age) was calculated [15].

2.1. Nutritional assessment

BMI was calculated at admission as weight/height^2. We measured mid-arm circumference (MAC) and triceps skinfold (TSF) using a Holtain lipocaliper and calculated mid-arm muscle area (MAMA). Anthropometric parameters were compared within sex and age categories for the adult population of the Western Canary Islands [16]. Calf circumference was measured on the dominant leg.

Subjective nutritional assessment included examination of the muscle mass of the upper and lower limbs and of the temporal muscle, defining two degrees of atrophy (severe, moderate), and absence of atrophy. We assigned 2, 1 and 0 points to each category, respectively. Bichat's pad and subcutaneous fat atrophy were scored in the same way. Thus, a subjective nutritional score (SNS) was obtained for each patient based on the sum of the assigned points. As previously reported, a score of 0–2 was considered normal, 3–4 points indicated mild malnutrition, and higher than 4 points indicated severe malnutrition. We also defined a muscular component of subjective score (M-SNS) considering only the 6 points of muscle assessment [17].

2.2. DEXA

We performed a body study composition using DEXA scan (Lunar Prodigy with software version encore 12.30; GE, Madison, WI) and determined lean and fat mass and bone mineral density (BMD). Appendicular lean mass (ALM) was determined and corrected by height^2. We considered four reference limits: first, those proposed by Baumgartner in the Rosetta study (7.26 kg/m2 in males and 5.45 kg/m2 in females) [8]; second, those proposed in the NHANESIII study (6.19 kg/m2 in males and 4.73 kg/m2 in females) [18], third a low ALM under the 10th percentile (5.11 kg/m2 in males and 4.53 kg/m2 in females), and fourth an ALM under the 5th percentile (4.78 kg/m2 in males and 4.17 kg/m2 in females).

2.3. Assessment of physical muscle performance

From two days after the admission lower-extremity function was assessed by measuring gait speed, standing balance, and five times sit-to-stand test [13].

A 10 m walk at the subjects' normal pace was timed. Speed was determined on the 6 middle meters after 2 accelerating m and before the last 2 m. The subjects were given a score of 0 when it was not possible to perform the test due to limited physical conditions; a score of 1 when velocity was less than 0.8 m/s; and a score of 2 when velocity was equal to or higher than 0.8 m/s. In 28 patients, it was not possible to perform the test due to limited physical conditions; in this case, velocity was computed as 0 m/s.

For standing balance tests, patients were asked to attempt to maintain their feet in the side-by-side, semi-tandem (heel of one foot beside the big toe of the other foot), and tandem (heel of one foot directly in front of the other foot) positions for 10 s each. The subjects were given a score of 0 if any standing was not possible of 1 if they could hold a side-by-side standing position or a semi-tandem position, and a score of 2 if they could hold a tandem position.

Subjects were asked to stand up from a sitting position once; if they successfully rose from the chair, they were asked to stand up and sit down five times. The subjects were given a score of 0 when it was not possible to stand up; a score of 1 if they stand up and sit down between 1 and 4 times; and a score of 2 when they stand up and sit down five times. With the summation of the scores of standing balance, walking speed, and ability to rise from a chair we calculated a modified Short Physical Performance Battery score between 0 and 6 points.

Dominant arm hand grip strength was determined using a Collin's dynamometer, selecting the best of three measurements. As a reference, we took the median value of 400 healthy volunteers, 196 men and 204 women aged between 20 and 29 years; the median values (interquartile range) of HGS were 35 (25–40) kg in males and 10 (6.3–15) kg in women [7]. Moreover, we assessed mobility as the self-reported ability to climb stairs, and to walk a distance of 3, 30, 300 or 3000 m.

2.4. Disability and frailty

We asked about the ability to perform the basic activities of daily living (ADLs) and the instrumental activities of daily living (IADLs) [19].

Frailty was assessed using the 7-point Clinical Frailty Scale of the Canadian Study of Health and Aging (CFS-CHSA). Patients were classified in the following models: 1.- Very fit. 2.- Well (without active disease) 3.- Well (with treated comorbid disease, disease symptoms are well controlled). 4.- Apparently vulnerable (not frankly dependent but with disease symptoms). 5.- Mildly frail (with limited dependence for IADLs) 6.- Moderately frail (help is needed with ADLs). 7.- Severely frail (completely dependent for the ADLs) [20].

Table 1
Female patients were older and frailer and had lower muscle mass and worse physical function. On the other hand, male patients showed higher comorbidity.

	Female	Male	z-MWU	p
	n = 81	n = 106		
	(n) X±SEM	(n) X±SEM		
Age (years)	(81) 77.3 ± 0.7	(106) 75.1 ± 0.6	2.47	0.014
SNS	(81) 4.62 ± 0.2	(106) 3.75 ± 0.2	2.67	0.008
SNS-M	(81) 3.77 ± 0.2	(105) 2.91 ± 0.2	3.47	0.001
MAMA	(81) 79.8 ± 2.9	(104) 88.9 ± 2.5	2.67	0.008
HGS %	(81) 19.9 ± 4.9	(105) 31.0 ± 2.6	5.27	<0.001
Gait speed m/s	(80) 0.40 ± 0.04	(102) 0.59 ± 0.03	3.96	<0.001
Standing balance	(80) 1.81 ± 0.2	(103) 2.61 ± 0.1	4.01	<0.001
Stand up	(80) 2.55 ± 0.2	(103) 3.36 ± 0.1	3.79	<0.001
SPPB	(80) 2.70 ± 0.2	(101) 3.56 ± 0.1	7.83	<0.001
ADL	(80) 6.99 ± 0.2	(104) 7.67 ± 0.1	3.03	0.002
IADL	(80) 5.01 ± 0.3	(104) 5.87 ± 0.2	2.92	0.003
CFS-CSHA	(81) 3.62 ± 0.2	(105) 2.55 ± 0.1	4.75	<0.001
Charlson index	(80) 2.58 ± 0.2	(106) 3.32 ± 0.2	2.21	0.027

	Female	Male	CHI-2c	p	Odd Ratio
	n = 81	n = 106			
Age > 80 years	28/81 (34.6%)	20/106 (18.9%)	5.14	0.023	2.27 (1.16–4.42)
SNS >2	67/81 (82.7%)	73/106 (68.9%)	3.97	0.046	2.30 (1.14–4.67)
SNS-M >4	33/81 (40.7%)	16/105 (15.2%)	14.0	<0.001	3.83 (1.91–7.63)
HGS < 20%	60/81 (74.1)	43/105 (41.0%)	19.0	<0.001	4.11 (2.19–7.75)
Inability to walk 300 m	26/81 (32.1%)	7/106 (6.6%)	18.8	<0.001	6.66 (2.72–16.4)
Inability to climb stairs	23/81 (28.4%)	6/106 (5.7%)	16.4	<0.001	6.62 (2.54–17.2)
Walking test not performed	19/80 (23.8%)	9/102 (8.8%)	6.57	0.010	3.22 (1.37–7.58)
Inability to stand up	19/80 (23.8%)	8/103 (7.8%)	7.92	0.005	3.70 (1.52–9.01)
Unable to rise from chair	21/80 (26.3%)	10/104 (9.6%)	7.78	0.005	3.34 (1.47–7.58)
SPPB 0	17/80 (21.3%)	6/101 (5.9%)	8.10	0.004	4.27 (1.60–11.4)
CFS-CSHA >4	25/81 (30.9%)	12/105 (11.4%)	9.65	0.002	3.46 (1.61–7.41)
IADL <7	42/80 (52.5%)	32/104 (30.8%)	8.00	0.005	2.49 (1.36–4.55)
ADL <5	13/80 (16.3%)	4/104 (3.8%)	6.88	0.009	4.85 (1.52–15.6)
Charlson >3	17/80 (21.3%)	44/106 (41.5%)	7.60	0.006	2.63 (1.36–5.09)

SEM: Standard Error of the Mean; MWU: Mann–Whitney U test; Chi-2c: Chi squared test with correction for continuity; SNS: Subjective Nutritional Score; SNS-M: Muscle component of Subjective Nutritional Score; MAMA: Mid Arm Muscle Area as percentage of standard of each sex; HGS: Hand Grip Strength as percentage of the standard in each sex; SPPB: Shorth Physical Performance Battery; ADL: Activities of Daily Living Scale; IADL: Instrumental Activities of Daily Living Scale; CFS-CSHA: Clinical Frailty Scale of Canadian Study of Health and Aging.

2.5. Statistical analysis (SPSS 22.0)

As most variables were not normally distributed, we used non-parametric tests such as Chi-2, Fisher Exact Test (FET), Kruskal–Wallis, Mann–Whitney U and Spearman correlation as necessary. All patients were followed (after discharge) by chart hospital revisions and telephone call; Kaplan–Meier curves and log rank test were performed to assess differences in survival after inclusion. Cox regression with covariate survival analysis was performed to discern which parameters yielded independent prognostic value.

Methods were carried out in accordance to established guidelines. The study was approved by the Hospital Universitario de Canarias Research and Ethics Board; informed consent was obtained from all patients or their relatives in the case of cognitive impairment.

3. Results

We included 187 patients, 106 men and 81 women, mean age of 76.1 ± 0.5 years. Patients showed a high prevalence of malnutrition 74.9% with a moderate impairment of the subjective assessment and 40.5% with a MAMA under the 10° percentile; muscle function impairment as a HGS <20% in 55.4% and a gait speed <0.8 m/s in 80.8%; disability, one or more failures in IADL in 40.2% and one or more failures in ADL in 17.9%; frailty as a CFS-CSHA > 4 in 19.9%; and a comorbidity Charlson index >2 in 54.3%, The more frequent diseases were a history of coronary disease, 35 (18.7%), stroke, 17 (9.1%), peripheral arterial disease, 25 (13.4%); cardiovascular risk factors: hypertension, 148 (79.1%), dyslipidemia, 104 (56.6%), obesity (BMI ≥ 30 kg/m2), 59 (31.7%), diabetes mellitus, 81 (43.3%) and smoking, 59 (31.6%); congestive heart failure, 72 (38.5%), COPD, 35 (18.7%), cancer, 33 (17.6%), alcohol abuse, 48 (25.7%), renal failure, 46 (24.6%), and dementia in 11 (5.9%) patients. The most frequent infections at admission were pneumonia in 36 (19.3%) and urinary tract infection in 27 cases (14.4%).

Women were older; with greater loss of muscle mass; worst physical muscle function as shown by hand grip strength, gait speed, standing balance and stand-up; frailer with higher CSF-CSHA and disabled as IADL and ADL. In contrast, men showed higher comorbidity Charlson index and mortality (Tables 1 and 2).

Only 3 (1.6%) patients died in hospital and 16 (8.6%) died one hundred days after admission. On long term follow up, 89 patients died with a survival at the end of the follow up of 43% and a

Table 2
Data with short and long-term prognostic value in elderly hospitalized patients.

	100 days mortality	CHI-2c	p	RR (OR)	Log Rank	p	RR (HR)
Male	8/106 (7.5%)	0.76	NS		5.37	0.021	1.67 (1.08–2.59)
Female	8/81 (9.9%)						
Charlson > 2	12/101 (11.9)	2.18	*0.140 NS*		17.1	<0.001	2.60 (1.62–4.15)
Charlson ≤ 2	26/145 (17.9%)						
Nutrition							
Serum albumin<3.5 g/dl	13/91 (3.3%)	5.55	0.018	4.89 (1.34–17.8)	6.28	0.012.	1.72 (1.12–2.63)
Serum albumin≥3.5 g/dl	3/91 (16.8%)						
SNS > 2	0/47 (0%)	FET	0.013	&	7.18	0.007	2.14 (1.21–3.79)
SNS ≤ 2	16/140 (11.4%)						
M-SNS > 4	7/49 (14.3%)	FET	*0.135 NS*		8.66	0.003	1.91 (1.23–2.95)
M-SNS ≤ 4	9/137 (6.6%)						
MAMA < 10th percentile	10/75 (13.3%)	2.58	*0.108 NS*		7.45	0.006	1.79 (1.17–2.72)
MAMA > 10th percentile	6/110 (5.5%)						
TSF < 5th percentile	4/13 (30.8%)	5.91	0.015	5.92 (1.59–22.2)	9.11	0.003	2.78 (1.39–5.55)
TSF > 5th percentile	12/172 (7.0%)						
Calf circumference Q1	7/ 40 (17.5%)	FET	0.049	3.23 (1.12–9.30)	7.54	0.006	1.88 (1.20–2.98)
Calf circumference Q234	9/146 (6.2%)						
DEXA							
Low LAM-DXA Rosseta	12/112 (13.0%)	1.05	0.306 NS		2.14	0.144	
Normal LAM-DXA Rosseta	4/75 (5.3%)						
Low LAM-DXA NHANESIII	7/54 (13.0%)	FET	0.246 NS		8.85	0.003	1.89 (1.23–2.89)
Normal LAM-DXA NHANESIII	9/133 (6.8%)						
LAM-DXA<5° percentile	2/9 (22.2%)	FET	0.173 NS		7.15	0.007	2.76 (1.27–6.00)
LAM-DXA>5° percentile	14/176 (6.5%)						
LAM-DXA<10° percentile	5/18 (27.8%)	FET	0.010	5.52 (1.67–18.3)	10.2	0.001	2.53 (1.40–4.56)
LAM-DXA>10° percentile	11/169 (6.5%)						
LTM-DXA<15° percentile	6/28 (21.4%)	FET	0.018	4.06 (1.34–12.3)	3.88	0.049	1.69 (1.00–2.87)
LTM-DXA>15° percentile	10/159 (6.3%)						
LTM-DXA>90° percentile	27/169 (16.0%)	FET	1.00 NS		10.9	0.001	2.56 (1.44–4.57)
LTM-DXA<90° percentile	1/18 (5.6%)						
FTM-DXA<20° percentile	7/37 (18.9%)	FET	0.020	3.66 (1.26–10.6)	4.80	0.028	1.69 (1.05–2.72)
FTM-DXA>20° percentile	9/150 (6.0%)						
Pelvis BMD-<20° percentile	8/37 (21%)	FET	0.004	4.90 (1.70–14.1) 713 days	11.2	0.001	2.16 (1.36–3.43)
Pelvis BMD->20° percentile	8/150 (5.3%)						
Physical muscle function							
Gait speed < 0.8 m/s	14/147 (9.5%)	0.15	NS		3.98	0.046	1.94 (1.00–3.74)
Gait speed ≥ 0.8 m/s	2/35 (5.7%)						
Hand grip < 20%	12/103 (11.7%)	1.93	*0.165 NS*		0.21	NS	
Hand grip ≥ 20%	4/83 (4.8%)						
Standing balance = 0	5/27 (18.5%)	FET	*0.065 NS*		5.70	0.017	1.89 (1.11–3.22)
Standing balance > 0	11/156 (7.1%)						
Stand up = 0-2	8/39 (19.4%)	FET	0.007	4.42 (1.54–12.7)	7.67	0.006	1.91 (1.19–3.05)
Stand up = 3-5	8/145 (5.5%)						
SPPB = 0	5/23 (21.7%)	FET	0.036	3.72 (1.16–11.9)	9.05	0.003	2.26 (1.31–3.91)
SPPB = 1-6	11/158 (7.0%)						
To walk < 30m/day	1/11 (9.1%)	FET	NS		5.26	0.023	2.28 (1.10–4.72)
To walk 30–3000m	15/176 (8.5%)						
Did not climb stairs	3/29 (10.3%)	FET	NS		4.99	0.025	175 (1.06–2.88)
Climbed stairs	48/219 (21.9%)						
Frailty and disability							
Frailty CFS-CSHA 5-7	5/37 (13.5%)	0.750	NS		6.95	0.008	1.85 (1.16–2.94)
Frailty CFS-CSHA 1-4	11/149 (7.4%)						
IADL = 0-6	9/74 (12.2%)	1.21	NS		11.9	0.001	2.07 (1.36–3.16)
IADL = 7	7/110 (7.4%)						
ADL = 0-4	3/17 (17.6%)	0.85	NS		7.10	0.008	2.19 (1.21–3.95)
ADL = 5-8	13/167 (7.8%)						

Chi-2c: Chi squared test with correction for continuity; FET: Fisher's Exact Test; SNS: Subjective Nutritional Score; M-SNS: Muscle component of Subjective Nutritional Score; MAMA: Mid Arm Muscle Area; TSF: Triceps Skin Fold; Q1: First quartile; Low LAM-DXA Rosseta: Low lean appendicular mass assessed by dual energy X ray absorptiometry according Rosseta study data; Low LAM-DXA NHANESIII: Low lean appendicular mass assessed by dual energy X ray absorptiometry according NHANESIII study data; LTM: Lean Total Mass; FTM: fat total mass; BMD: Bone Mineral Density; SPPB: Shorth Physical Performance Battery; HGS: Hand Grip Strength; CFS-CSHA: Clinical Frailty Scale of Canadian Study of Health and Aging; IADL instrumental activities of daily living scale; ADL activities of daily living scale.
& The odds ratio of SNS >2 cannot be calculated as one of the observed frequencies was 0.

median survival of 1266 days. Table 2 shows that survival was related to male sex, comorbidity, malnutrition, impaired physical muscle function, frailty and disability, with a closer relationship with mortality at long term follow up than 100 days after admission.

Lean and fat mass assessed by DEXA and BMD were all related to survival. Regarding lean mass and survival, the cut-off limits for appendicular lean mass proposed by Baumgartner in the Rosetta study (7.26 kg/m2 in males and 5.45 kg/m2 in females) were not related in any case to mortality. The reference limits proposed by the NHANESIII study (6.19 kg/m2 in males and 4.73 kg/m2 in females) were significantly related to long term mortality, but a better relationship was obtained with appendicular lean mass under the 10th percentile (5.11 kg/m2 in males and 4.53 kg/m2 in females) and 5th percentile (4.78 kg/m2 in males and 4.17 kg/m2 in females) (see Fig. 1). Total lean mass was also related to survival but with a U-

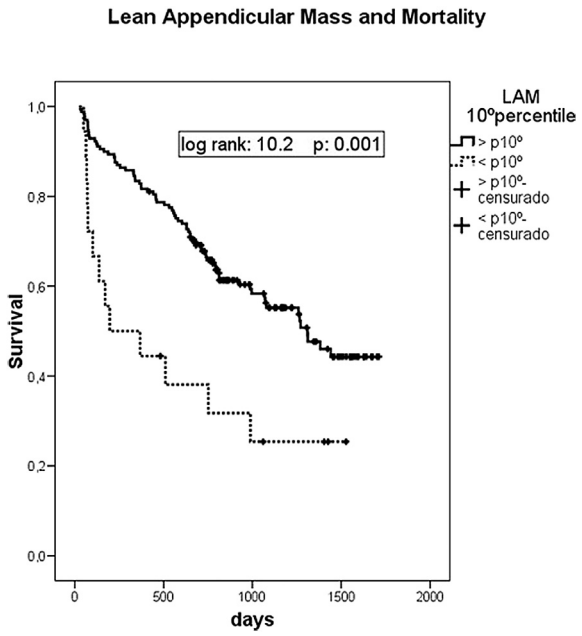

Fig. 1. These patients with a lean appendicular mass under the 10th percentile (5.11 kg/m2 in males and 4.53 kg/m2 in females) showed a poor long-term survival; half of patients died after 197 days.

shaped form. Both patients with a total lean mass under the 15th percentile and over the 90th percentile, showed increased long-term mortality. Those patients with a total lean mass over the 90th percentile also showed a higher prevalence of edema, 44% vs 13%.

As we can see in Table 3, all the data determined by DEXA, lean and fat mass and BMD were closely correlated with other nutritional data and physical function tests but not with Charlson comorbidity index.

Searching for independent long-term mortality, we performed a multivariate analysis (Table 4). We included the following variables: (1) comorbidity (Charlson index >2); (2) male sex; (3) Lean Appendicular Mass-DXA <10° percentile; (4) Malnutrition as SNS>2 (5) Incapacity to perform any of the three muscle function tests: walk test, balance and stand up; (6) Frailty as a CFS-CSHA > 4; (7) self-reported inability to climb stairs and (8) inability to walk every day more than 30 m. The first five items listed and in this order were variables with independent predictive value.

DEXA study was not performed in 120 patients so they were excluded. These patients were older and showed a worse nutritional status, muscle function, frailty, and disability.

4. Discussion

Our elderly hospitalized patients with high comorbidity were frequently malnourished, frail, disabled, and did poorly on physical function tests. Regarding prognosis we found a scarce mortality in the short term whereas a high mortality at the long term follow up. Only three patients died at hospital. This low mortality must be attributed to the study selection criteria, as patients with terminal disease, impaired consciousness, severity of illness, and these in whom DEXA could not be performed were excluded. However, at the long term follow up 89 patients died with a median survival of 1266 days related to aging and comorbidity.

Women were older, with less muscle mass, weaker, more disabled and frailer (Table 1), nevertheless male sex has a higher mortality, perhaps partially related to higher comorbidity of male sex [7,21]. However, as it was shown in multivariate analysis male sex prognostic value is independent from comorbidity.

We have observed a close relationship between survival and malnutrition in its diverse assessment forms, such as classic anthropometrics, calf circumference, subjective assessment and DEXA. It is remarkable that the impact of body composition studies on mortality has rarely been evaluated in acute hospitalized patients, however, DEXA data such as lean and fat mass and bone mineral density showed the best relationship with mortality [3,22–25]. Regarding lean mass loss, the prognostic value depends on the cut-off limits, being more precise at low cut off limits, 5th and 10th lean appendicular mass percentiles, whereas higher limits as these proposed by the Rosseta study lacks predictive value in our patients [8]. Lower values of total lean mass also showed predictive value on mortality. Nevertheless, patients with increased total lean mass (>90th percentile) showed a

Table 3
Correlation analysis (Spearman rho) between DEXA components appendicular and total lean mass, total fat mass, pelvis and total bone density (all DEXA components as median percentage) and nutritional status, muscle physical function tests and comorbidity. Besides comorbidity assessed by Charlson index, all these variables were significantly correlated among them; the correlation shown by pelvis BMD is noteworthy.

		Total lean mass	Apend lean mass	Total fat mass	Total BMD	Pelvis BMD
BMI	rho	0.524	0.539	0.763	0.418	0.466
	p	<0.001	<0.001	<0.001	<0.001	<0.001
SNS	rho	0.364	0.394	0.501	0.406	0.436
	p	<0.001	<0.001	<0.001	<0.001	<0.001
MAMA	rho	0.429	0.428	0.480	0.332	0.357
	p	<0.001	<0.001	<0.001	<0.001	<0.001
Calf perimeter	rho	0.579	0.620	0.654	0.397	0.492
	p	<0.001	<0.001	<0.001	<0.001	<0.001
HGS	rho	0.435	0.374	0.330	0.397	0.402
	p	<0.001	<0.001	<0.001	<0.001	<0.001
speed	rho	0.174	0.206	0.099	0.186	0.305
	p	0.019	0.005	0.185	0.012	<0.001
Balance	rho	0.085	0.181	0.147	0.148	0.288
	p	0.250	0.031	0.047	0.046	<0,001
Stand up	rho	0.182	0.225	0.143	0.199	0.313
	p	0.014	0.002	0.053	0.007	<0,001
SPPB	rho	0.174	0.231	0.158	0.186	0.344
	p	0.019	0.002	0.033	0.012	<0,001
Charlson	rho	0.099	0.006	0.183	0.049	0.076
	p	0.179	0.938	0.013	0.503	0.302

BMI: Body Mass Index; SNS: Subjective Nutritional Score; MAMA: mid arm muscular area; HGS: Hand Grip Strength by dynamometry; speed: gait speed developed on walking test; Stand up: stand up five times; SPPB: short physical performance battery.

Table 4
Multivariate analysis of long term survival (Cox regression).

	Long term survival			
	Univariate CHI2	Wald	p	HR (CI 95%)
Variables with independent predictive value				
Charlson index > 2	17.8	10.9	0.001	2.35 (1.41–3.90)
SPPB = 0	8.86	6.39	0.012	2.12 (1.18–3.79)
SNS >2	7.07	5.41	0.020	2.04 (1.12–3.73)
Lean Appendicular Mass-DXA <10° percentile	11.0	4.95	0.026	2.02 (1.09–3.76)
Male sex	4.31	4.69	0.030	1.70 (1.05–2.74)
Variables without independent predictive value				
Frailty CFS-CSHA 5-7	7.85			
Did not climb stairs	5.90			
To walk < 30m/day	5.59			

HR: Hazard ratio; CI 95%: 95% confidence interval; CFS-CSHA: Clinical Frailty Scale of Canadian Scale of Health and Aging; SNS: Subjective Nutritional Score; SPPB: Shorth Physical Performance Battery.

paradoxical higher mortality, which may be explained by edema as water was included in lean mass when assessed by DEXA [26,27]. We have not observed this fact with lean appendicular mass, an advantage therefore for this assessment method.

As we can see in Table 3, BMD is related to nutrition and with physical function. It is remarkable that the relationship of pelvis BMD is better than that of total BMD, and also with mortality. The interpretation may be that muscle activity of the legs increases muscle mass and mineral density at the pelvic bone where muscles are attached. So, we may explain the relationship between lack of muscle mass and function and osteoporosis, osteosarcopenia, and how together they configure the dysmobility syndrome [28].

Regarding physical muscle function tests, we found a relationship between hand grip strength and all data of nutritional status including lean and fat mass assessed by DEXA and BMD, and with lower extremities tests such as gait speed, balance and stand up test. All these tests have prognostic value as they are related to short- and long-term survival. The self-referred inability to climb stairs or to walk more than 30 m in a day [29,30], frailty and inability to perform activities of daily living also have long-term prognostic value. However, surprisingly in contrast with similar studies we did not find a significant relationship between hand grip strength and survival [1,2,7,31].

Comorbidity Charlson index did not correlate with nutrition or physical muscle function data (Table 3). On multivariate analysis (Table 4) it is the best prognostic factor and the first to be selected as a variable with independent predictive value. As there was no correlation between the Charlson index and nutrition and physical function tests, it did not lessen the prognostic value of these variables (SPPB = 0, SNS >2 and ALM under 10th percentile) which were included in the second, third and fourth places, respectively. Finally, male sex which is a well-known prognostic factor, women were frailer and disabled, but lived longer [7,21].

So, although DEXA scans are difficult to perform in elderly hospitalized patients and leads to additional costs, they have, besides other nutritional and muscle function data, have an incontestable prognostic value but with lower than custom cut-off reference limits.

Declarations of interest

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Author contributions

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