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ORIGINAL ARTICLE

Inflammation and nutritional status as predictors of physical performance and strength loss during hospitalization

AP Rossi, V Zanandrea, E Zoico, M Zanardo, C Caliari, S Confente, S Gabriele, G Mazzali, F Fantin and M Zamboni

OBJECTIVES: The aim of this study was to examine changes in physical performance and handgrip strength during hospitalization as well as to evaluate their interrelationship with inflammatory and nutritional status.

DESIGN: Data were available on 302 elderly patients with a mean age of 80.83 ± 7.14 years. Handgrip strength, gait speed and chair-stand test were assessed at admission and before discharge. In all subjects, serum CRP values and Mini Nutritional Assessment scores were also evaluated.

RESULTS: The risk of worsening in chair-stand test performance was 4.2 (95% confidence interval (CI): 1.574–11.310) for subjects with simultaneous presence of malnutrition and CRP ⩾ 50 and 3.3 mg/dl (95% CI: 1.127–9.423) for subjects with CRP ⩾ 50 mg/l not malnourished in comparison with subjects with Mini Nutritional Assessment (MNA) ⩾ 24 and CRP ⩽ 10 mg/l. The risk of handgrip strength loss was 8.8 (95% CI: 3.545–21.662) in subjects with simultaneous presence of malnutrition and CRP ⩾ 50 and 2.9 mg/dl (95% CI: 1.223–6.783) in subjects with CRP ⩾ 50 mg/l not malnourished in comparison with subjects with MNA ⩾ 24 and CRP ⩽ 10 mg/l.

CONCLUSIONS: Simultaneous presence of high CRP values and malnutrition determines an additive effect on muscle strength loss and physical performance.

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INTRODUCTION

Identification of patients at higher risk for functional decline during hospitalization is important to prevent development of adverse outcomes, but traditional clinical assessment has shown limited capacity to discriminate people at high risk.[1] Hospitalization is associated with decline in function and muscle performance. The mechanisms involved are not yet fully known.[2] Inflammation has been proposed as a key factor that induces muscle waste and leads to physical function and strength decline, with a direct effect on imbalance between protein anabolism and catabolism.[3,4] Furthermore, even nutritional problems are shown to be related to impaired functional ability.[5] The aim of this study was to examine changes in physical performance and handgrip strength during hospitalization as well as to evaluate their interrelationship with inflammatory and nutritional status.

MATERIALS AND METHODS

A total of 541 patients were recruited from the acute care Geriatrics Division of Verona. Patients were eligible for inclusion if they were aged ⩾65 years, were admitted on a weekday, consented to participate in the study within 24 h of admission and did not present mild or severe cognitive impairment.[6] Seventy-eight patients were excluded because they did not consent or because of serious medical conditions. In 161 subjects it was not possible to assess performance tests at both admission and discharge for worsening clinical conditions during hospitalization. Analysis was performed in a final sample of 302 patients with complete handgrip test data at admission (day 2.31 ± 2.02) and discharge (day 10.54 ± 4.38). In a subsample of 226 subjects it was also possible to assess performance tests (gait speed and chair-stand) at admission and discharge. Comorbidity as evaluated with the Charlson index, Mini Nutritional Assessment (MNA) scale, activity of daily living (ADL), instrumental activity of daily living (IADL) and Barthel index, cause of hospitalization and days of bed rest were also recorded.[6] Venous blood samples for CRP, hemoglobin and albumin levels were obtained after overnight fasting. Comparisons of performance variables and handgrip strength upon hospital admission and discharge were made using the paired *t*-test.

A one-way analysis of variance was performed to evaluate differences in baseline characteristics of the study sample stratified into six categories on the basis of CRP at hospital admission (⩽10, < 50, > 10 and ⩾ 50 mg/l) and MNA (⩾24 or < 24).

With a binary regression, the risk for deterioration in gait speed, chair-stand and handgrip tests for different categories compared with the reference group was calculated considering gait speed, chair stand and handgrip as dependent variables (categorized as stable/improved vs worsened) and age, gender, values of gait speed, chair stand or handgrip at hospital admission, hypoalbuminemia, days of bed rest, weight, Charlson index, cause of hospitalization and ADL as independent variables. Statistical analyses were performed using SPSS 20.0 (IBM SPSS inc., Chicago, IL, USA).

RESULTS

Table 1 shows the characteristics of the study population stratified by serum CRP and MNA values at hospital admission.

Three hundred and two subjects of both sexes (37.1% female) were included, with a mean age of 80.83 ± 7.14 years.

During hospitalization a significant increase in time to perform gait speed test of about 0.24 s ($P < 0.05$) and a reduction in handgrip strength of about 0.5 kg ($P < 0.001$) were observed.

In a binary logistic model, considering chair-stand categories as dependent variables (stable/improved vs worsened) and MNA/CRP categories, adjusted for age, sex, time to perform chair-stand test at baseline, days of bed rest, weight, Charlson index, cause of hospitalization, ADL and presence of anemia and hypoalbuminemia, as independent variables, the risk of worsening in chair-stand performance was 4.2 (95% confidence interval

Section of Geriatrics, Department of Medicine, Division of Geriatrics, University of Verona, Verona, Italy. Correspondence: Dr AP Rossi, Section of Geriatrics, Department of Medicine, Division of Geriatrics, University of Verona, Ospedale Maggiore, Piazzale Stefani 1, Verona 37126, Italy.
E-mail: andrea.rossi@hotmail.it
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Table 1. Characteristics of the study population

	N	*Mean ± s.d. CRP ⩽ 10 mg/l MNA ⩾ 24* n = *93*	*Mean ± s.d. CRP ⩽ 10 mg/l MNA < 24*[a] n = *48*	*Mean ± s.d. 10 mg/ l < CRP < 50 mg/l MNA ⩾ 24*[a] n = *39*	*Mean ± s.d. 10 mg/ l < CRP < 50 mg/l MNA < 24*[a] n = *25*	*Mean ± s.d. CRP ⩾ 50 mg/l MNA ⩾ 24*[a] n = *47*	*Mean ± s.d. CRP ⩾ 50 mg/l MNA < 24*[a] n = *50*
Age (years)	302	78.81 ± 7.00	80.48 ± 7.05	81.54 ± 7.31*	82.52 ± 6.66*	82.91 ± 6.74**	81.74 ± 6.81*
Sex (women%)	302	61 (65.59%)	28 (58.33%)	18 (46.15%)*	16 (64%)	33 (70.21%)	34 (68%)
Weight (kg)	302	74.38 ± 14.47	66.87 ± 15.86**	73.83 ± 15.71	63.93 ± 10.45***	71.11 ± 14.24	68.65 ± 14.10*
Height (m)	302	1.65 ± 0.07	1.66 ± 0.08	1.64 ± 0.09	1.65 ± 0.07	1.66 ± 0.08	1.66 ± 0.08
BMI (kg/m^2)	302	27.10 ± 4.82	24.02 ± 4.77***	27.48 ± 5.77	23.38 ± 3.14***	25.70 ± 4.43	24.90 ± 4.20**
ADL/6	302	5.71 ± 0.79	4.75 ± 1.79***	5.87 ± 0.41	4.2 ± 2.08***	5.40 ± 1.41	4.48 ± 1.99***
IADL/8	302	6.81 ± 1.75	4.31 ± 2.9***	6.15 ± 2.08	3.48 ± 2.40***	5.57 ± 2.64**	4.42 ± 2.94***
GDS/30	302	2.37 ± 2.16	3.85 ± 3.02***	2.69 ± 2.69	3.76 ± 3.36 *	2.49 ± 2.65	3.44 ± 2.71*
MMSE/30	302	27.06 ± 3.22	23.70 ± 5.99***	26.73 ± 2.98	22.86 ± 6.49***	25.84 ± 4.03	23.93 ± 5.72*
MNA/30	302	28.89 ± 1.79	16.04 ± 5.39***	29.06 ± 1.51	15.64 ± 5.93***	28.85 ± 1.69	17.76 ± 6.43***
Barthel index	302	68.2 ± 21.09	50.83 ± 29.65***	57.95 ± 23.02***	46.40 ± 31.24***	53.09 ± 25.93	52.30 ± 27.28***
Charlson index	302	2.84 ± 1.78	2.94 ± 1.89	2.72 ± 1.30	3.56 ± 2.29	3.11 ± 1.90	4.28 ± 2.86***
Time to perform gait speed test (s)	226	6.23 ± 2.44	8.04 ± 4.57**	6.97 ± 2.62	8.27 ± 4.80*	6.26 ± 2.01	8.32 ± 4.07*
Time to perform chair-stand test (s)	226	17.54 ± 8.68	19.62 ± 13.73	25.85 ± 19.81*	31.58 ± 22.24**	20.33 ± 14.86	19.15 ± 12.29
Handgrip(kg)	302	22.45 ± 8.38	17.60 ± 8.49***	18.44 ± 7.28*	16.24 ± 8.38***	19.98 ± 8.09	17.04 ± 6.15***
CRP (mg/l)	302	2.95 ± 2.22	3.41 ± 2.50	22.90 ± 14.60***	24.06 ± 11.32***	94.62 ± 69.79***	105.10 ± 75.62***
Hemoglobin (g/dl)	302	12.24 ± 1.84	12.79 ± 4.31	12.24 ± 1.95	11.79 ± 2.01	11.83 ± 1.38	10.62 ± 1.60***
Hematocrit (%)	302	37.06 ± 6.21	37.57 ± 6.93	37.54 ± 5.90	36.36 ± 5.83	36.67 ± 4.17	33.39 ± 4.87***
Albumin (g/l)	302	34.73 ± 4.64	33.59 ± 4.99	32.31 ± 5.53*	31.16 ± 4.05***	29.80 ± 5.51***	27.16 ± 6.63***

Abbreviations: ADL, activity of daily living; BMI, body mass index; CRP, C-reactive protein; GDS, Geriatric Depression Scale; IADL, instrumental activity of daily living; MNA, Mini Nutritional Assessment; MMSE, Mini, Mental State Examination. [a]In comparison with reference category (CRP ⩽ 10 mg/l and MNA ⩾ 24).*$P < 0.05$; **$P < 0.01$; ***$P < 0.001$.Data are all expressed as percentages or as mean (s.d.) if noted.

(CI): 1.574–11.310) for subjects with simultaneous presence of malnutrition and CRP ⩾ 50 and 3.3 mg/dl (95% CI: 1.127–9.423) for subjects with CRP ⩾ 50 mg/l not malnourished (Figure 1). There was a nonsignificant interaction between MNA and CRP on the risk for worsening chair-stand performance (F = 1.050; $P = 0.35$).

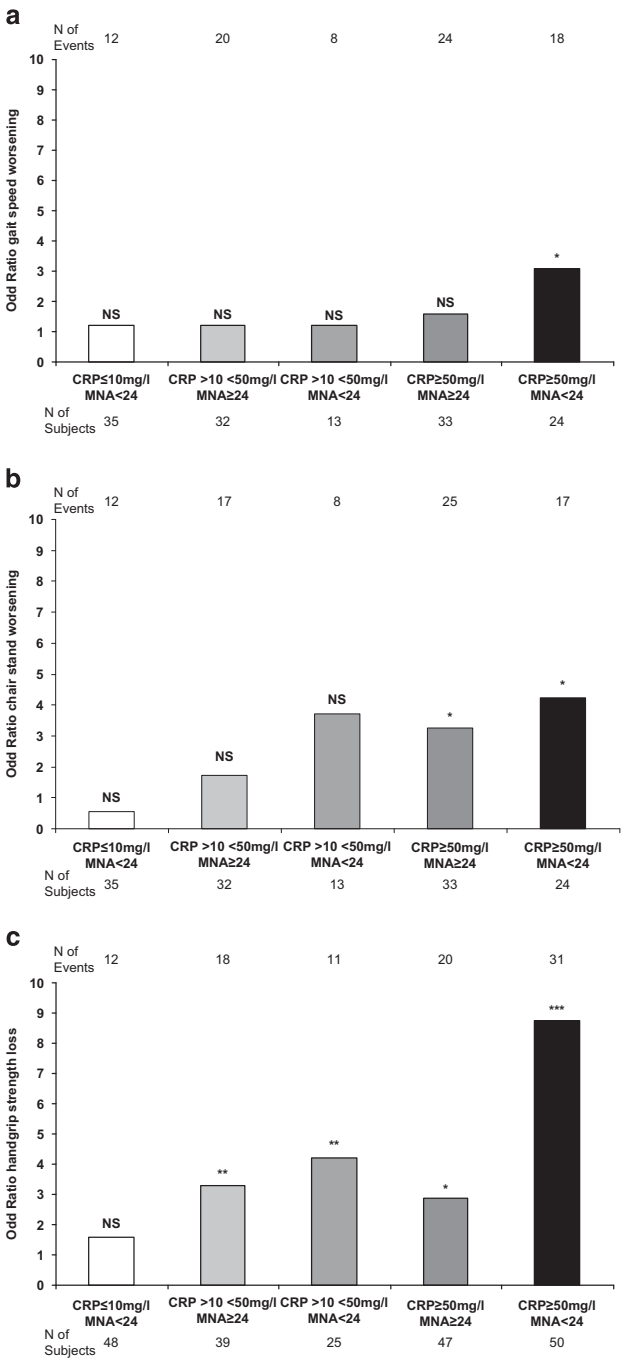

Figure 1. Odds ratios of gait speed loss (**a**), chair-stand loss (**b**) and handgrip strength loss (**c**) in different inflammation and malnutrition categories, considering subjects with MNA ⩾ 24 and CRP < 10 mg/l as reference category, adjusted for age, sex, time to perform chair-stand test at baseline, days of bed rest, weight, Charlson index, cause of hospitalization, ADL and presence of anemia and hypoalbuminemia. A number of events (number of subjects with gait speed worsening, chair-stand worsening and handgrip strength loss) have been indicated. ***$P < 0.001$, **$P < 0.001$, *$P < 0.05$.

Considering handgrip categories with a binary logistic model as the dependent variable (stable/improved vs worsened) along with the same independent variables, risk for handgrip loss was 8.8 (95% CI: 3.545–21.662) for malnourished subjects with CRP ⩾ 50 mg/dl, 2.9 (95% CI: 1.223–6.783) for not malnourished subjects with CRP ⩾ 50 mg/l, 4.2 (95% CI: 1.485–11.902) for malnourished subjects with CRP < 50 and > 10 mg/l and 3.3 (95% CI: 1.389–7.796) for not malnourished subjects with CRP < 50 and > 10 mg/l (Figure 1). A significant interaction between malnutrition and CRP classes on the risk for handgrip loss was observed (F = 3.03; $P = 0.03$).

DISCUSSION

In this study, participants with a high level of CRP at hospital admission and malnutrition showed greater risk for physical performance and muscle strength worsening during hospitalization compared with subjects presenting inflammation or malnutrition alone.

Our results are consistent with previous studies that evaluated the relationship between muscle strength, physical performance and inflammatory status in community-dwelling elderly subjects, showing that high levels of interleukin-6 and CRP are associated with increased risk for strength loss.[3,7]

Only a few studies have evaluated loss of muscle strength in relation to inflammatory status in hospitalized elderly patients. In a sample of 620 patients, Norman *et al*.[4] showed an independent association between inflammation and handgrip strength. Our results are in line with that of Bautmans *et al*.[2] who observed higher muscle strength loss in subjects with CRP > 10 mg/l.

There is evidence on the link between strength loss and risk for nutritional disorders.[5] In a recent study involving patients admitted to a nursing home, a relationship between BMI < 20 kg/m^2, reduced muscle strength and higher disability was observed.[8]

In our study sample, the simultaneous presence of malnutrition and inflammatory status was associated with a more than additive effect on the risk for handgrip strength loss. Our results are partially in line with previous reports from Bartali *et al*.[9] who observed an association between low daily caloric intake and reduction in muscle strength, walking speed and fragility in the population of the InChianti study.

Some limitations of our study must be acknowledged. First, loss of muscle mass was not evaluated in our population. Second, only CRP and no other inflammatory markers more specifically related to muscle loss, such as interleukin-6, tumor necrosis factor-α and interleukin-1β, were measured for this analysis.

In conclusion, the results of our study show that inflammatory state and presence of malnutrition are associated with greater loss of physical performance and muscle strength in elderly hospitalized patients.

As hospitalization has been shown in elderly subjects to be a stressful event leading to loss of autonomy, identification of subjects at higher disability risk through evaluation of systemic inflammation and malnutrition may be a useful screening tool in clinical practice.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHOR CONTRIBUTIONS

R, VZ, FF and MZ: analysis and interpretation of data and preparation of manuscript; MZ, EZ, FF and GM: consulted on study design, recruited subjects and edited the manuscript; AR: edited the manuscript; CC, SC, SG, VZ and MZ: acquisition of subjects, collection of data and review of the manuscript.

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